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CONCERNING VARIATIONS IN ANIMALS AND PLANTS

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WITHIN any given species of animals or plants as occurring in nature, variations of many sorts may appear. No one individual is the exact image of another, either in structure or in function. In theory, at least, no one cell is exactly like another, no one chromosome the exact duplicate of a mother or a sister chromosome. Moreover, no one group or aggregation of individuals is exactly like another, if separated from it by time or space. In the classification of variations we may naturally divide them into individual variations and collective variations. Collective variations are produced by the extension of certain types of individual variations from generation to generation. These form the basis of new species, as gaps are produced within the series by isolation or by the death of intermediate forms.

Individual variations are again sharply divided into those which are inborn or blastogenetic, and those which are acquired or ontogenetic, produced by the direct influence of environment or by the reaction of the organism from external conditions.

The inborn variations arising from differences in the original germ cells, male, female or both, or from results of their combination or amphimixis, may be again subdivided as fluctuations, saltations, monstrosities and hybridizations. So far as we know it is alone from inborn variations, as perpetuated by heredity, as sifted by natural selection and as protected by bionomic isolation, that collective variations, nascent species and new species originate.

Fluctuations

The small differences, numerous but slight, and never wanting, which distinguish one individual from another of the same species

have been termed fluctuations. These occur in every individual, in every organ and practically in every direction. They are traceable, on the one hand, to differences in the germ cell, and in the process of mitosis or cleavage to which it is subject, and, on the other, to the fact of amphimixis, or double parentage, universal in the higher animals and plants. These fluctuations are hereditary, but their existence is easily obscured by the fact that the slight variations in the one parent rarely coincide with those of the other. In the progress of a species, individual fluctuations tend to neutralize one another.

It is, however, certain that fluctuations can be rapidly intensified and rendered stable by the process of selection, either natural or artificial. While it is probably true that few species originate by the process of selection alone, it is almost certain that it is possible for selection alone to produce groups equivalent to those we call species. There is apparently no limit to what man can do by the persistent preservation of favorable or desirable fluctuations. The same results must occur in nature when the same process takes place if it ever does take place. A slight advantage on the side of any special fluctuation will change the average variation in that direction and in time make the character permanent.

One of the first noteworthy studies of fluctuations as distinguished from climatic, environmental and geographic variations was that made by Dr. J. A. Allen in his paper on the 'Mammals and Winter Birds of East Florida,' published in 1871. In this paper Dr. Allen gives measurements of many specimens of various species of common birds, with a view to ascertaining the normal rate of variation. In this regard, the study of birds is much more instructive than that of most groups, because a bird of any species rapidly reaches a natural stature. It is affected in its growth by environment or food conditions much less than the members of most other groups. The well-fed bird reaches its normal stature, the ill-fed or injured bird dies, and the bird changes little with growth, its adult condition being once attained. Among adult male birds, characters due to accidents of condition are reduced to the minimum.

Dr. Allen finds that each part is subject to an ordinary variation of from 15 to 20 per cent. in its measurements, this in specimens of the same age and sex; at the same time each part varies independently of the others, even each feather of the wing and tail. Each toe may vary for itself, and the bill and the claws are subject to the same deviations from the normal. Color variations are equally well marked, and the variations within the species as represented in a single locality are often as great as those which actually distinguish species. In birds with streaks or spots, these markings vary in size, form and number, each individual having its own traits, which persist through the seasonal changes of plumage. It is part of the art of the faunal

naturalist or systematist to determine which of these characters represent individual variations and which are associated with distinctness of species.

In general, the conditions of a species may be compared to a target filled with marks of shot. The bull's-eye represents the normal position of the shot, but variations in every direction occur. As one goes away from the bull's-eye the shot marks are fewer in number, but some of them may fall at a considerable distance from the center or average. Sometimes the majority may lie on one side of the center. This would indicate a continuous influence acting in one direction, as the wind affecting the direction of the bullets. Among animals a similar deviation from the usual may indicate a climatic effect, or the effect of natural selection under different conditions. That either of these influences may cause a mass variation within a group admits of no shadow of doubt. Nor is there any doubt that fluctuations within the species may and do constantly go as far as to equal the usual distinction between one species and another. The sole test of a species is in the relative permanence of its group of characters, not in the extent of its deviations from some other group. And in almost every case where the actual origin or cause of separation of one species from the next can be traced, it is found to have a geographic factor. Doubtless favorable fluctuations could be added together until those possessing them should be segregated from the mass about them, but we have no certain knowledge of any such cases. Doubtless individual fluctuations (saltations) could be so extreme as at once to segregate their possessor from all its neighbors. Doubtless new species might and perhaps do originate in that way, but out of the hundreds of thousands of species studied in nature, not one is certainly known to have had such an origin. But let any group of individuals be separated from their fellows, no matter how, in time the individuals remaining will come to an equilibrium with a different center of variation or a different arrangement of average characters from those possessed by the parent stock. The characters of any species represent the equilibrium or result attained by the forces of heredity and the operations of local natural selection.

We may again divide the traits of the fluctuations or minor variations of the individual into three classes, those useful, those indifferent and those harmful. A useful variation may cause the survival of the individual; a harmful variation may cause its destruction.

In considering the traits of a species, these classes of characters are reduced to two. Adaptive characters—those associated with the well-being of the individual—and non-adaptive, or indifferent characters—those which have no evident relation to utility. Characters positively harmful are always eliminated so far as the species is concerned.

In the actual work of the description of species, we recognize at

once that adaptive characters are older than the non-adaptive characters. This is true, even though the adaptive character itself be a relatively recent one. The flying-fishes flew before the group was split up into thirty species. Yet the enlargement of the fins of these fishes is one of the latest products in fish evolution.

The species of Hawaiian birds of the family of Drepanidæ are among the latest results of bird development. Yet these birds were divided into genera characterized by the form of the bill, each type of bill being adapted to a special purpose long before the present actual species were themselves differentiated.

All the orioles build hanging nests, and all are adapted alike in structure and instinct to their mode of life. All the sparrows and finches have bills fitted for cracking seeds. And these features of adaptation preceded the subdivision of orioles or sparrows into their present genera and species. In general, the traits by which we distinguish species are non-adaptive characters, while the features of adaptation are most distinctly traceable in structures common to many species, the characters of genera or of families in zoology.

But in this we find certain paradoxes. In studying the characters of members of a zoological family, we find that the most distinctly adaptive characters are relatively recent. It is a truism that physiological characters have a lower systematic value than characters not related to the character of life processes. The traits that fit animals for a special kind of food or for a special kind of topography are recognized as of low value in taxonomy. In other words, special adaptations are of relatively recent origin. General adaptations are older than special adaptations. Hence they have a higher value in classification. A flying-fish is fitted to swim in the water before it is adapted to leap in the air. But all general adaptations began some time as special ones. General adaptations have become so ingrained in the life of animals that they are, in a sense, invisible to the systematist. He passes them by as matters of course, directing his attention to special adaptations or to special peculiarities which seem to be devoid of utility. The ancient adaptations are not even considered as adaptations at all, when we say that adaptive or physiological characters have a low value in classification. And it is from this fact that the seeming paradox arises.

Again the adaptive character in the race or species may appear to be of very recent origin. The Southdown sheep of England had tawny faces before they acquired their present traits of wool or mutton. The explanation of such cases is this: an adaptation is never finished, a more rigid selection may at any time enforce a more rigid adaptation. Natural selection acts as a constant influence. It may be varied or intensified under new circumstances, as when it is directed by the will of man, when it becomes artificial selection. And under the

influence of artificial selection a non-adaptive or indifferent character becomes adaptive or selective. Among those animals or plants which submit readily to domestication almost any natural species, distinguished by non-adaptive characters, could be reproduced with all its traits by a process of carefully controlled selective breeding.

Saltations[1]

It has long been known that individual fluctuations of an extreme degree sometimes occur, and that these may be to a degree persistent in heredity. Of such nature was the Ancon sheep, the iceberg blackberry and numerous other races or forms known in the domestication of animals or the cultivation of plants. The generally normal structure of such individuals distinguishes them from monstrosities, which are usually freaks of development rather than of heredity.

The name 'saltation,' or in recent years 'mutation,' has been applied to extreme fluctuation, the immediate cause of which is unknown. The experiments of Dr. Hugo de Vries on the saltations of the descendants of an American form of evening primrose (*Œnothera lamarckiana*) have recently drawn general attention again to the possibility that saltation has had a large part in the process of formation of species. As to this it may be said that the possible variation within each species is much greater than the range of the individuals which actually survive. The condition of domestication favors the development of extreme variation, because such individuals may be preserved from interbreeding with the mass, and they may survive even if their characters are unfavorable to competition in the struggle for existence. Among plants it is noticed that new soil and new conditions seem to favor large variation in the progeny, although the traits thus produced are rarely if ever hereditary. Cases more or less analogous to those noted by Dr. de Vries are not rare in horticulture. The cross-breeding of variant forms favors the appearance of new forms. Among actual species in a state of nature, there are very few which seem likely to have arisen by a sudden leap or mutation. The past and the future of de Vries's evening primroses are yet to be shown, and it is not at all unlikely that the original *Œnothera lamarckiana* found in a field near Amsterdam was a hybrid stock, a product of the florist, the behavior of its progeny being not unlike that which appears in the progeny of hybrids. The species called by de Vries *Œnothera lamarckiana* is not known in its wild state anywhere in North America, the parent region of the species of evening primrose or *Œnothera*. It is, moreover, known that the seeds of hybrids of an American species, probably *Œnothera biennis*, the common evening primrose, with other

[1] The name saltation has been long used for wide fluctuations without recognizable cause. The more recent name mutation chosen by de Vries has been in use for years for the slow changes appearing in geological time.

American species produced by Mr. Burbank, have been in past years sold in the cities of Germany. In any event, we have as yet no reason to assume that the various mutants of the evening primrose are in any sense comparable to the wild species of the same group now existing in America.

While saltation remains as one of the probable sources of specific difference, its actual relation to the process of species-forming in nature is yet to be proved.

Dr. de Vries's assertion that the process of natural selection is mainly a conflict between saltatory offshoots and not a competition between similar individuals ('intraspecific instead of interspecific competition') is hardly justified by the facts. The real conflict is that of the individuals maintaining life against the pressure of external conditions.

In the struggle for existence, each individual survives which can. The close presence of other similar individuals and that of unlike individuals are alike parts of the environment which each individual that leaves progeny has in some degree succeeded in conquering. This conquest takes place through adaptation to the actual conditions, concession to the actual environment.

It is highly probable that saltations in general are of the same nature as fluctuations, and that they occur in nature far more commonly than has been supposed. Unless in some way protected by isolation, the traits thus developed are likely to be swamped and lost by interbreeding with the mass. But it is conceivable that they are not always thus lost, as a very favorable variation may overwhelm the mass. But it is also clear that isolation of some sort would be usually, if not always, essential to any survival of a group possessing saltatory characters.

Hybridization

In crossing related species, new forms arise, having in part a blend or a mosaic of the characters of the two parent species, in part other traits or characters, the origin of which may not be clearly traced. Usually the second generation shows a great range of variation, often deviating farther in some respects from the average type than was the case with either of the original parents. The progeny of these variants may also vary widely. It has been sought to define the laws governing these variations. When only a few easily recognized characters are concerned, it has been possible to trace a certain regularity, conforming in general to the Mendelian law. But different species differ not in one way, but in a thousand ways. These traits are so interwoven and so variously related, some of them cumulative and some contradictory, that in most cases no law determining which characters shall be dominant in each case and which recessive can be made out. While the

Mendelian law may be of universal application, it is in a few cases only that its facts can be clearly seen.

In heterogeneous hybridization or the crossing of distantly related forms, all sorts of results are reached, according to the nature of the forms in question. In few cases does the progeny become mature, and still more rarely does it prove fertile. If the plans of structure inherited from the two parents do not coalesce with reasonable completeness, nothing comes of the development of the progeny. Thus the strawberry may be readily crossed with the raspberry. The resultant plant grows and blossoms, but the divergent lines of heredity can not agree on the structure of the fruit, and the plant is wholly sterile.

In Mr. Burbank's cross of the European walnut (*Juglans regia*) with the California walnut (*Juglans Californica*), the first generation shows a certain blending of the traits of one species with those of the other. In the next generation appears every conceivable kind of variation in every feature of the plant and in every function of its organs.

Among artificial hybrids of different species a few are fertile and breed true to the parent stock. Among these are the Primus berry, a cross between the blackberry and raspberry, and the Logan berry, a chance cross between a cultivated raspberry and a California blackberry (*Rubus vitifolia*) growing outside a garden fence in Santa Cruz, California.

These two plants might be properly called distinct species, if we were not aware of the circumstances of their actual origin. But hybrids rarely form distinct species in nature. European writers have defined numerous hybrids among the fresh-water Cyprinidæ of the continent of Europe. Nothing of the sort occurs in the same group in America, and the evidence for hybridization needs at least re-examination.

Among American birds we have three notable cases: In the genus *Helminthophaga* (*Helminthophila* Ridgway), a group of American wood warblers, three nominal species have been described, each of which is usually regarded not as a true species, but as a hybrid of two of the common forms. One of these, called *Helminthophaga cincinnatiensis* Langdon, is 'obviously a hybrid' between *Helminthophaga pinus* and *Oporornis formosa*. *Helminthophaga lawrencei* Herrick, known from a few specimens, is perhaps a hybrid of *Helminthophaga pinus* and *H. chrysoptera*. *Helminthophaga leucobronchialis* Brewster, known from some scores of examples from various localities, is probably also a hybrid of the same two species. "It is probable," says Mr. Ridgway, "that both in the case of this form and *H. lawrencei*, that dichromatism, as well as hybridism, enters into the question of their origin. While *H. pinus* apparently exhibits rarely a white and gray phase (instead of olive and green) and *H. chrysoptera* as rarely a

yellow and olive green instead of white and gray phase, the two species interbreed to such an extent not only with one another, but each with *H. leucobronchialis* and *H. lawrencei* (the hybrids being fertile *inter se*), that the problem is a very complicated one and therefore most difficult to work out satisfactorily."

Mr. W. E. D. Scott has lately maintained that these forms or species of warblers are not hybrids, but the results of saltations or mutations in the sense in which the word is defined by Dr. de Vries. But this view of the case finds little favor among ornithologists who continue to regard these forms as true hybrids.

In a single genus of marine fishes, the pargo or snapper (*Lutianus*), the types of certain nominal species have been suspected to be hybrids, because they show a perfect blend of the traits of well-known and related species found in the same waters. Of *Lutianus lutianoides*, from Cuba, one specimen is known. It is thought to be a hybrid of *Lutianus apodus* and *Ocyurus chrysurus*. Of *Lutianus brachypterus*, from New Providence, there is one specimen, thought to be a hybrid of *Lutianus griseus* and *Lutianus synagris*. Two specimens of *Lutianus ambiguus* have been found in Cuba. It is thought to be a hybrid of *Lutianus synagris* with *Ocyurus chrysurus*. Nothing is known as to the fertility of any of these forms. The record of such hybrids shows how rare is the occurrence of this phenomenon among fishes.

Along the boundary line of the western distribution of the golden winged flicker (*Colaptes auratus*) of the eastern United States, the species overlaps the range of the red-shafted flicker (*Colaptes cafer*), a species which replaces the first in California and Mexico. Among other differences, the former has the shafts of the wings and tail yellow. The other has these shafts red. But where the species meet individuals occur variously mixed. Some even have the tail red on one side and yellow on the other. These individuals have been recorded as hybrids (*Colaptes auratus hybridus*), and this origin is in fact probable.

In the Sonoran region, along the meeting line of *Colaptes cafer* (*var. collaris*), similar crossing with a Mexican golden woodpecker (*Colaptes chrysoides*) is said to take place.

Hybrids of wild plants sometimes occur, but the cases are rare, and in general it may be doubted whether hybridization has had any appreciable part in the origin of species.

Selection

The individuals possessing any sort of variations, large or small, fluctuation or mutation, are subject to the struggle for existence. This is the test of fitness. To live and to leave progeny means in itself a high degree of adaptation. Every form of struggle, as indicated above, is a struggle with the conditions of life, the competitive features, however, being inevitable accessory conditions. All struggle is in fact

intraspecific, that of individuals within the species. When members of related species enter into competition in the same region, the struggle becomes in a degree interspecific, one between the species themselves through their actual representatives. But as there is practically no cooperation among members of the same species, except in the family or band relation of the higher animals, the struggle must be in fact always individual. The struggle against the environment in general is in its essence non-competitive, but in the crowd of animals and plants competition becomes part of the environment. Some seeds, we are told, fell on stony ground, but the plants died because they had no depth of earth. Some fell among thorns, and the thorns grew up and choked them. Still others doubtless perished because they were planted too close together. These three causes of the destruction of the great body of animals and plants, the competition with like forms, that with unlike forms, and the pressure of the environment, are present everywhere with all life in varying degrees, and by it all life is forced into lines of adaptation.

With vital characters, selection preserves those which have no utility by the simple action of heredity. All Southdown sheep have tawny faces, although this trait bears no relation to the short firm wool or to the fat and tender flesh, for which traits the Southdown sheep are bred and valued.

In similar fashion, many indifferent characters are traceable in the various breeds and strains of domesticated animals and cultivated plants. We may presume that similar characters in wild animals and plants have been similarly carried along by inheritance from ancestors possessing them. This phenomenon I have elsewhere called 'the survival of the existing.' The actual traits are reproduced by heredity without regard to any question of fitness.

Dichromatism

The phenomena of dichromatism belong to the category of individual variation. In the vast majority of animals, we have the dimorphism of sex. In the beginning the embryo is sexless. From the beginning, by forces imperfectly understood, its development must be directed in one way or another. It must assume the structures and functions of one or the other sex. With certain insects, a polymorphic condition exists. With bees, the caste of workers or atrophic females exists, together with the type of drone and queen. With some ants, still other types of individuals occur, but the dimorphism of sex, or the polymorphism of the division of labor, rests on influences perhaps not altogether inherent in the structure of the parent cell.

In dichromatism, the individual from the first shows one or another of two color patterns peculiar to the species. The screech owls are some gray, some rusty red, within the same species, even in the same nest.

In the same fashion, gray squirrels and black squirrels belong to the same species. In the same species of globe fish, *Tetraodon nigropunctatus,* some individuals are gray, and some citron yellow. In another species, *Tetraodon setosus,* some are gray, some yellow and some deep blue.

In a West Indian species of bass-like fish, strangely misnamed *Hypoplectrus unicolor,* an extraordinary polychromatism occurs. All the known individuals belonging to one or another of the following color forms which have been called species:

a. Soft dorsal checkered or spotted with pale blue or crossed by blue lines (these occasionally obsolete).

b. Body dusky, the head and belly orange, the top of the head olivaceous; a black spot on each side of caudal peduncle close behind dorsal; black band or spot in front of eye not bordered by blue; cheeks, opercle and breast with vertical lines of metallic blue; dorsal yellowish; pectoral and caudal orange; a black spot in the axil; upper margin of pectoral blue; anal orange with blue border; ventral greenish, its base orange. *Unicolor* (= *Maculiferus*).

bb. Body all violet with 5 or 6 more or less distinct black cross bands, the middle one broadest, covering the space from the fourth to the tenth dorsal spine and meeting its fellow under the belly; the band at the nape broad and saddle-like, bounded by 2 pale cross streaks on nape, opercle and cheeks; snout pale, a pale shade across it; ventrals pale or dark; other fins, except spinous dorsal, mostly pale.

c. Cheek with a blue band before eye and some blue spots before it. *Puella.*

cc. Cheek without blue band; no blue spots on snout; colors duller. *Vitulinus.*

bbb. Body and head yellow anteriorly; body abruptly black posteriorly, the black extending forward to a wavy line reaching from first dorsal spine to vent; a broad dark-blue band in front of eye, bordered by sky blue; fins chiefly orange; ventral and anal bordered by sky blue. *Pinnavarius.*

aa. Soft dorsal plain, without distinct blue lines or spots.

d. Preorbital region with 1 or more dark-blue stripes, bordered by bright sky blue (not fading in spirits).

e. Body yellow anteriorly, black posteriorly, the black extending forward to a line joining the nape and last anal ray; fins orange; a single blue-black stripe or spot in front of eye, ocellated with sky blue; caudal peduncle very dark above. *Guttavarius.*

ee. Body all orange yellow, fins orange; snout and lower jaw blue; 2 blue stripes, each bordered with sky blue, before the eye. *Gummigutta.*

eee. Body saffron yellow, orange posteriorly; snout with blue streaks and some blue dots. *Crocotus.*

dd. Preorbital region without blue stripes.

f. Preorbital region with violet spots; a round black spot on side of caudal peduncle; dorsal light greenish; body light olive green above, reddish below; pectorals pale yellow, the first ray blue; ventrals, anal and caudal light orange. *Aberrans.*

ff. Preorbital region without distinct violet spots.

g. General color blackish, brown or yellowish—not indigo blue.
h. Color brownish, the middle of the front of body yellowish; fins all yellow except the ventral, which are black. *Accensus*.
hh. Color yellowish pink; caudal and pectorals pale; ventrals and anal bright light blue. *Affinis*.
gg. Color of body black with violet shades.
i. Pectoral and caudal fins abruptly bright yellow. *Chlorurus*.
ii. Pectoral and caudal fins violet black like the rest of the body. *Nigricans*.
j. General color deep indigo blue everywhere on body and fins; body with 4 to 6 broad cross bars of darker blue.
k. Cheeks plain, without distinct stripes. *Indigo*.
kk. Cheeks with a dark-blue suborbital band between 2 bands of clear blue. *Bovinus*.

What the significance of this extraordinary condition may be, is entirely unknown, nor do we know the determinant causes of dichromatism. It is sufficient for the purposes of this paper to refer to the fact.

Ontogenetic Variations

A vast range of variations are ontogenetic, or dependent on influences affecting directly the life of the individual. These are not hereditary in the judgment of the present writer, and therefore they are not direct factors in the formation of species. Many investigators take a different view, believing in the direct inheritance of acquired characters, or of the effects of environmental or functional conditions, the familiar tenets of 'Neo-Lamarckism' or progressive heredity.

These ontogenetic variations are, strictly speaking, individual, appearing as collective only when many individuals have been subjected to the same conditions. They may be divided into environmental variations and functional variations, two categories which can not always be clearly separated, as variations due to food conditions partake of the nature of both.

In the epoch-making paper quoted above, and in other publications, Dr. Allen shows that climatic influences affect the averages in measurements and in color among birds. For example, in several species of birds, the total length is greater in specimens from the north, while the bills and toes are actually longer in southern specimens. That this condition is due to the influence of climate on development is shown by the fact that numerous species are affected in the same way. It is noticed also that specimens from the northeast and the northwest of the United States are darker in color than those from the interior, and again that red shades are more common in the arid southwest. Similar effects have been recently shown by a study of species of wasps. They may be produced at will by subjecting the larvæ and pupæ of

insects to artificial heat and cold. The butterflies of the glacial regions and those developed in an ice-chest have a pale coloration, and a warm environment deepens the pigment.

It has not been shown that any of these effects are hereditary, or that they constitute a factor in the formation of species, although climatic effects may enter into the process of natural selection. I have before me a series of woodpeckers selected by a student (Mr. Hubert Jenkins), which illustrates at once climatic and other subspecific variation. The collection represents the species known as hairy woodpecker (*Dryobates villosus*). Taking the typical form *villosus,* from the eastern United States, we note that specimens from further south (*auduboni*) are smaller in every way, but otherwise similar. To the northward, in Canada and on the Arctic Sea, the birds are much larger, (*leucomelas*) ten to eleven inches in length instead of eight to nine, while the feet are scarcely if at all enlarged. In all these the space before the eye is black, and the belly is darker in specimens from the region having the most rainfall. In the Bahamas is a form still smaller, seven to eight inches long (*maynardi*), with the space behind the bill white. Further westward, in all woodpeckers of this species, the white spots on the wing coverts, characteristic of the eastern forms, nearly or quite disappear, leaving the feathers plain black. Here again the northernmost forms are largest, *harrisi* of the Californian-Alaskan region being nine to ten inches long, those from California being nearly white below, those from the Vancouver region smoky gray, darkest when the rainfall is greatest. The Mexican form (*jardini*) is seven to eight inches long, but in the moist regions of Central America it too becomes deep smoky brown. Of these traits, those relating to the size of the bird and the smoky coloration of its lower parts may probably be regarded as climatic. Whether a bird born of northern parents would reach its full stature in the south, or whether it would grow up with white belly plumage in a rainy district, are both open to question. The experiment can hardly be tested with woodpeckers, but some other group may offer conditions more favorable to artificial breeding.

On the other hand, the loss in the western birds of the white wing spots characteristic of *villosus* and its subspecies, *leucomelas, auduboni,* and *maynardi,* can have apparently no climatic cause, but is one of the results of the primitive separation of the forms on the two sides of the Rocky Mountains, or more properly of the treeless plains where woodpeckers of this type are not found.

It may be noticed that in the related but much smaller American species known as the downy woodpecker (*Dryobates pubescens*), the eastern forms (*pubescens*) have also the wing coverts profusely spotted with white, while in the western form (*gairdneri*) the wing coverts, as in the western forms of *Dryobates villosus,* are nearly or quite plain

black. The ornithologists have not yet agreed on a subdivision of this species into larger northern or smaller southern subspecies, nor have the darker specimens from regions of greater rainfall received distinct names. Similar variations have been noted in the Hudsonian chickadee (*Parus hudsonius*) and in other birds of the northern forests. To what extent the variations seemingly due to direct influence of climate are hereditary has not been ascertained.

While the embryo may be deprived of its normal growth momentum, the effect of unfavorable conditions is spent with a few generations of normal life, and no direct change in the heredity of the race is known to arise from the direct effects of environment.

Food Variations of Silkworms

Elaborate experiments in the effects of the underfeeding of silkworms have been made by Professor Vernon L. Kellogg and Mrs. Ruby Green Smith. The following synopsis of the results is given by Mrs. Smith.

The effects of underfeeding (which have been studied in heredity) upon the immediate generation fed on half the normal supply of food, may be classified as (1) physiological and as (2) those subject to quantitative measurement. They are as follows:

I. Physiological:

1. Larval moltings, pupation and emergence of adult delayed and metamorphosis thereby prolonged.
2. Fertility reduced (as indicated by number of eggs laid, number hatching and number of individuals reaching maturity).
3. Mortality in all stages greater than among normally-fed individuals.

II. Variations from the normal which are subject to quantitative measurements.

1. Reduction in size and weight of all parts in all stages (exemplified statistically and quantitatively by larval widths and lengths, by moth wing expanse, and by larval, pupal and adult weights).
2. Reduction in quantity of silk produced, the cocoons being below normal in dimensions, thickness and weight.
3. Degeneration of wing veins slightly more marked than in normally-fed individuals (economy of material being practised to advantage in these comparatively useless structures).

The results of underfeeding in heredity have been studied in three generations derived from the original underfed great-grandparental stock. The characters which the underfeeding was known to affect were studied in a comparative way in 1904 among numerous lots.

Heredity of underfeeding among silkworms whose make-up may be summarized as follows:

1. Lots accustomed always to years of plenty.
2. Lots in which some one of the four generations experienced famine.
3. Lots in which famine was experienced in two alternate or two successive years.
4. Lots in which famine was experienced in three successive or in one alternate and two successive years.

CONCLUSIONS.

Throughout these lots the conclusions were consistent, and were in brief as follows:

1. The lingering effects of a single generation of underfeeding may be definitely traced to the third generation, although the progeny of the underfed generation be given the optimum amount of food.

2. The power of recovery through generous feeding exhibited by the progeny of individuals subjected to famine is so extensive that three generations of plenty succeeding one generation of famine are sufficient to bring about the complete recovery of the race from the dwarfing consequent upon a generation of famine. Thus individuals of the fourth generation — the great-grandchildren of the starvelings — are the compeers in every respect of individuals of normal ancestral feeding. It is highly probable, but not yet proved, that recovery is possible even after three generations of famine.
3. The effects of famine grow less evident the further removed (in heredity) the individuals are from its occurrence in their ancestral history. Thus, in two lots having but one underfed generation in 4, a lot having the underfed generation 2 or 3 years previous would rank higher in all respects than one whose immediate parents were its only underfed ancestors.
4. A fourth generation on insufficient feeding has not yet been reared successfully in two years' trial. It is highly probable that the race cannot survive more than three generations of poor nourishment.

It will be noticed that the differences between the normally fed individuals and those subjected to famine are not species-making differences, as specific characters go with the Lepidoptera, there being no differences in color or patterns, or shape or venation of wings, or larval or adult ornamentation. If a species or race of silkworms were named on the basis of characters induced by famine, it would be a 'size' and 'season' species—a Lilliputian race of silkworms having a lengthy metamorphosis.

While at first glance these experiments might seem to offer an instance of the *inheritance of acquired characters*, it is, however, apparent that the underfeeding affects the nourishment and full development, not only of visible parts of the body, but also of the germ cells and all internal parts of the body. The germ cells need not be said, therefore, to have been influenced by the acquired somatic characters and to have transmitted them as such, but rather they may be said through their own lessened vitality to have produced progeny with characteristics so parallel to those of the parent soma as to make it appear an authentic case of the inheritance of acquired characters. We have, therefore, a case of transmission of imperfect nutrition, not one of true heredity, a distinction made clear by Weismann. Moreover, if acquired characters are really hereditary, their inheritance should last for more than three generations.

One interesting result of this experiment is that (in so far as silkworm testimony goes) temporary trying conditions do not handicap the race in the long run. It is even conceivable that the ultimate result of famine might be a strengthening of the race (physically speaking), the famine playing the part of a selective agent, preserving only the strong and adaptable.

Ontogenetic Species

Of like nature, but often far greater in degree, are the changes in the individual dependent on differences in food, in nurture or in surroundings generally. In the life of a plant the environmental variations may be so great as apparently to overshadow all the innate characters or peculiarities. With the higher animals the direct effect of environment is proportionately less, and it reaches its minimum among birds and the more specialized insects. Yet no individual of any species is without some traits of variation due entirely to environmental influences. In fact heredity does not repeat the traits of the parent, but merely the tendency to develop similar traits under similar conditions. Change utterly the conditions of growth, and the same heredity will show itself in very different results. Strictly speaking,

the characters of a species are not those which appear, but the ability to develop these characters under the conditions surrounding the ancestry of the individual.

But there is no evidence that the direct influence of environment is a factor in the separation of species, except as its results may be acted upon by natural selection. We have no reason to suppose that the environment of one generation determines the heredity of the next. It is true in a broad way that the ill-nourished offspring has weaker or less numerous offspring, but weak or strong, their hereditary traits are those of their actual parent stock.

The features of the 'ontogenetic species' or subspecies, have long been known under the name of 'convergence of characters,' 'parallelism' and 'analogous variation.' An 'ontogenetic species' is a group in which the likeness among the members is due, not to genetic connection, but to the exposure of the individuals to like conditions of development. Hence it should have no recognition in taxonomy, which deals with phylogenetic species and subspecies only. But no species is truly defined when only the usual characters, those developed under usual conditions, are considered. To know the species fully, we should know what qualities individuals may develop under all the varied relations of the environment in which they may be placed.

Ontogenetic species, however, tend to become phylogenetic, in isolation from the rest of their kind, by interbreeding among themselves, and under new conditions of selection. The real characters of the race thus formed may be wholly obscured by the more evident characters due to food conditions or to reaction from the environment. To test the characters, phylogenetic and ontogenetic, and to purge the system of species and subspecies founded on the latter, will be part of the work of the student of species for a long time to come.

Taking concrete illustrations—the Loch Leven trout, *Salmo levenensis*, recently discussed, is distinguished in its native waters by certain obvious characters. These disappear when the eggs are planted in brooks in England or in California, and the species develops as the common English brook trout. But it is conceivable that the obvious or ontogenetic traits of the Loch Leven trout are not the real or phylogenetic distinctions, and that the latter, more subtle, engendered through individual variation, inheritance, selection and isolation, really exist, although they have escaped the attention of ichthyologists.

After the species was planted in Yosemite Park in 1896, it remained for nine years unnoticed. In 1905, individuals sent to me were, so far as I could see, exactly like English brook trout. But it is conceivable that differences in food and water have caused slight ontogenetic distinctions. It is certain that in isolation from all parent stocks they will, in time, develop larger differences, which, after many thousand generations, will be specific or subspecific. At present, these

trout are quite unlike the native rainbow trout (*Salmo irideus gilberti*) of the Yosemite. The ontogenetic characters will perhaps approach those of the latter, but the phylogenetic movement may be in quite another direction.

Another ontogenetic species is the little char or trout, *Salvelinus tudes* Cope, from Unalaska. In Captain's Harbor, Unalaska, the Dolly Varden trout, *Salvelinus malma,* swarms in myriads, in fresh and salt water alike, reaching in the sea a weight of six to twelve pounds. A little open brook, which drops into the harbor by an impassable waterfall, contains also an abundance of Dolly Varden trout, mature at six inches and weighing but a few ounces. This is *Salvelinus tudes.* In the harbor the trout are gray with lighter gray spots, and fins scarcely rosy. In the brook, the trout are steel blue, with crimson spots and orange fins, striped with white and black. In all visible phylogenetic characters, the two forms of trout are one species. We have reason to believe that fry from the bay would grow up as dwarfs in the brook, and that the fry from the brook would be gray giants if developed in the sea.

But it is also supposable that in the complete isolation of the brook fishes, with free interbreeding, there would be some sort of phylogenetic bond. There may be a genuine subspecies, *tudes,* characterized not by small size, slender form and bright colors, but by other traits, which no one has found because no one has looked deeply enough.

In no group of vertebrates are the life characters more plastic than among the trout. The birds have traits far more definitely fixed. Yet differences in external conditions must produce certain results. I should not venture to suggest that the dusky woodpeckers or chickadees of the rainy forests of the northeast and northwest are purely ontogenetic species or that they should be erased from the systematic lists. But it will be a great advance in ornithology when we know what they really are and when we understand the real nature of the small-bodied, large-billed, southern races of other species of birds. It would be worth while to know if these are really ontogenetic purely, or if they are phylogenetic through 'progressive heredity,' the inheritance of acquired characters, such as the direct effects of climate or as the reaction from climatic influences. Or again, may there be a real phylogenetic bond through geographical segregation, its evidences obscured by the more conspicuous traits induced by like experiences? Or are there other influences still more subtle involved in the formation of isohumic or isothermic subspecies?

Functional Variations

Functional variations are variations produced in the individual by the use or disuse of organs. They are most marked in the most active

organisms, notably in man, in other mammals and in birds. They form a large factor in the development of the individual. The education and training of the individual man produces functional variations, as distinguished from innate peculiarities. But the groups characterized by functional variations are of the nature of 'ontogenetic species.' There is no evidence that the current of heredity is affected by changes of this kind, or that they have any direct effect in the formation of true species. At the most, use or disuse of organs seems to affect species only in an indirect way, as by the preservation of those most disposed to functional activity, and which by such activity have been able to meet better the demands of the environment.

Collective Variations

The preservation of individual variations with their extension to posterity gives rise to racial changes, and these to the larger variations which mark change in species.

Collective variations are chiefly of geographical or geological origin: Changes with space produce geographical species and subspecies. To this category belongs the vast majority of species and subspecies recognized in systematic zoology and botany. It is illustrated by the species of wood warbler (*Dendroica*) mentioned in a previous paper.

Changes with time produce geological mutations. It is a fact unquestionable that a species will change on its own grounds little by little with the lapse of time and the slow alteration of conditions of selection. Nations change, languages change, customs change, nothing is secure against the tooth of time. This is in general true, because with time alteration of environment takes place, events happen, there is an alteration of the stress of life and with this alteration all life may be modified.

That time-mutations in all forms of life do take place is beyond question, and some have regarded these slow changes as the chief agency in the formation of species. But the current of life does not flow in straight lines nor in an even current. Species are torn apart by obstacles, as streams are divided by rocks, and the rapidity of their formation is proportioned to the size of the obstacle and the alternations it produces in the flow of life.

We have some basis for the estimate of the duration of a species. When the great glacial Lake Bonneville occupied the basin of the Great Salt Lake, the same species of fishes and insects were found in all its tributaries. Now that these streams flow separately into a lifeless lake, the same species of fishes occur in them for the most part without alteration. One species of sucker (*Catostomus ardens*) and one chub (*Leuciscus lineatus*) are found unaltered throughout this region and in the Upper Snake River (above Shoshone Falls), into

which Lake Bonneville was once drained. Other species are left locally isolated, but in one species only (*Agosia adobe*) a small minnow of the clay bottoms can be shown to have undergone any alteration. But with the tiger beetle (*Cicindelæ*) a large number of species have been produced by isolation.

From the Bay of Panama 374 species of fishes are recorded in the recent monograph of Gilbert and Starks. Of these species, 204 are recorded also from the Gulf of California, while perhaps 50 others are represented in the more northern bay by closely related forms.

Comparing the fish faunas separated by the isthmus, we find the closest relation possible so far as families and genera are concerned. In this respect the resemblance is far closer than that between Panama and Chile, or Panama and Tahiti, or Panama and southern California. On the Atlantic side, similar conditions maintain, although the number of genera and species is far greater (about 1,200 species) in the West Indies than at Panama. This fact accords with the much larger extent of the West Indies, its varied groups of islands isolated by deep channels, and its near connection to the faunas of Brazil and the United States.

But it is also noteworthy that while the families of fishes are almost identical on the two shores of the isthmus of Panama, and the great majority of the genera also, yet the species are almost wholly different.

Taking the enumeration of Gilbert and Starks, we find that out of 374 species, 43 are found apparently unchanged on both sides of the isthmus; 265 are represented on the Atlantic side by closely related species—in most cases the nearest known relative of the Pacific species—while 64 have no near analogue in the Atlantic. Of the last group, some find their nearest relative to the northward or southward along the coast, and still others in the islands of Polynesia.

The almost unanimous opinion of recent students of the isthmus faunas finds the latest expression in the following words of Gilbert and Starks ('The Fishes of Panama Bay,' p. 205):

> The ichthyological evidence is overwhelmingly in favor of a former open communication between the two oceans, which must have become closed at a period sufficiently remote from the present to have permitted the specific differentiation of a very large majority of the forms involved. That this differentiation progressed at widely varying rates in different instances becomes at once apparent. A small minority (43) of the species[2] remain wholly unchanged so far as we have been able to determine that point. A larger number have become distinguished from their representatives of the opposite coast by minute (but not 'trivial') differences, which are wholly constant. From such representative forms we pass by imperceptible gradation to species much more widely separated, whose immediate relation in the past we can not confidently affirm. . . .
>
> It is obvious, however, that the striking resemblances between the two faunas are shown as well by slightly divergent as well as by identical species,

[2] 43, or 11 per cent. of the species found on the Pacific side; about 2.5 of the combined fauna.

and the evidence in favor of interoceanic connection is not weakened by an increase in the one list at the expense of the other. All evidence concurs in fixing the date of that connection at some time prior to the Pleistocene, probably in the early Miocene. When geological data shall be adequate definitely to determine that date, it will give us the best known measure of the rate of evolution in fishes.

Of the 82 families of fishes represented at Panama, all but three (Cerdalidæ, Cirrhitidæ and Nematistiidæ) occur also on the Atlantic side of Central America, while of the 218 genera of the Panama list, no fewer than 170 are common to both oceans. The well-developed families, Centropomidæ and Dactyloscopidæ, are peculiar to the two tropical faunas now separated by the Isthmus of Panama. It might be added that the families of Nematestudæ (one species) and Cerdalidæ (three species) are confined to the Panama region, while the Cirrhitidæ (one species) belongs to a group characteristic of the islands of Polynesia.

From this discussion, it is probable that even in isolation some species change very slowly, that with similar conditions the changes within isolated groups of a species may be parallel, and that the specific changes in different groups may progress with very different degrees of velocity. Natural selection apparently furnishes the motive power of change, but the initiative comes from variation and heredity, and its direction and final results depend on a multitude of conditions and circumstances of environment which are largely geographical, topographical or climatic in their nature.

Topographical Segregation

Topographical segregation may bring about the separation of subspecies or species in precisely the same manner as other methods of geographical isolation. An example is that of the deep-water trout of Lake Tahoe, *Salmo henshawi tahoënsis*. The ordinary Tahoe trout, *Salmo henshawi*, lives in the shallow parts of the lake, spawning in the streams. This form, larger in size, more robust in form and less spotted in color, lives in the depths of the lake, spawning near the shore. The difference between the two is not great, but is perhaps sufficient to justify the subspecific name (*tahoënsis*). The two are considered as different species by anglers.

A more strongly marked case, probably of earlier origin, is seen in several West Indian species of grouper or sea bass, belonging to the genus *Mycteroperca*. In these species, the shore forms have an olive-green color, while others, essentially similar, in deep water are crimson or scarlet. Thus *Mycteroperca venenosa*, the yellow-fin grouper, has a scarlet cognate form, *Mycteroperca venenosa apua*, *Mycteroperca tigris*, likewise green in shallow water, has its deep water representative in *M. tigris camelopardalis*. The same condition holds with *Mycteroperca olfax* of the Galapagos and its cognate *M. olfax ruberrima*. In another species of this type, the Guatívere, *Cephalopholis fulvus* of the West Indies, the shore form is dark olive, (*C. fulvus punctatus*), that found in deeper water is crimson (*C. fulvus ruber*),

while in still deeper water is a golden-yellow form, the original *Cephalopholis fulvus*. Similar relation of olive and red forms, or of black and yellow types, has been noticed in other groups of fishes.

In similar fashion, it is claimed that within the species lines of segregation may be set up on a physiological basis those of a certain type not breeding freely with those of other types. This theory is largely hypothetical. It is conceivably true under certain circumstances, but there is little evidence that any particular species has originated in that way.

It is beyond question that differences greater than those ordinarily separating distinct species may be produced by continuous conscious or unconscious selection on the part of man. To what extent these breeds would retain their characters under the leveling processes of nature, it is impossible to say in any particular case. On the other hand, in the nature of things, all of them are of very much more recent origin than competing species in nature. While it may be that no wild species has originated from human selection, it is true, on the other hand, that the races thus produced are the same in essence as the subspecies and species produced in nature. The same forces are at work, the basis of selection only being altered by man. The river flows according to the same laws over a natural ledge of rock or over an artificial dam.

Hybridization, as above shown, may produce species as well marked and as fertile as any natural species. But no wild species is known to have arisen from this cause, unless we regard the warbler, *Helminthophaga leucobronchialis*, as an established species.

A saltation or mutation, beginning with an individual, may extend its characteristics to a numerous progeny, thus forming the beginning of a species. But while this influence may in theory, or even in fact, have a large importance, it is not likely that many species originate in this way. There is no clear evidence that any wild species known to us has arisen from a sudden large individual variation or mutation.

Orthogenesis

A large number of unexplained, but apparently related, phenomena have been recorded under the name of determinate variation, or have been grouped together as examples of a process to which Eimer has applied the name of Orthogenesis.

Setting theory aside, these cases are essentially of this character. In geological times a certain number of genera appear, each one in a certain direction farther along than its predecessor. Very often a certain organ will be progressively more and more highly developed until a certain point, when it is progressively degraded or simplified in its structure. Examples of this are found among the ammonites, or cephalopods with coiled shells, the chambers in the cell elaborately

sculptured. Many illustrations are found in the group of fishes. Coats of mail may be built up step by step, genus after genus, and then gradually modified or abandoned. In the *Chætodon-Zanclus-Acanthurus-Balistes-Tetraodon-Diodon-Mola* series of fishes, we have a high development and specialization of the spinous dorsal followed by its entire loss step by step, with that of the ventral fin also. The scales, at first normal, are specialized to lancets, bony plates, spinules, and then gradually reduced to mere prickles and finally lost.

In the *Cirrhitus-Sebastes-Scorpæna-Cottus-Psychrolutes-Cyclopterus-Liparis-Paraliparis* series, we have a higher and higher specialization of fins and scales, with the final loss of the latter and a reduction of the fins to their lowest terms. Similar series connect the typical sharks with the rays. Other series among fishes begin with specialized forms, but end in the degeneration seen in multiplied and unspecialized vertebræ and fin rays. The well-known horse series and the series of monkeys and apes—each genus in certain lines being progressively more anthropoid—may be considered in this connection. In fishes, many of these series may be clearly traced among forms still existing, the most primitive as well as the most recent or degenerate types being still represented in the sea. But, in a general way, when the geological series is known, it is found to run more or less parallel in time to the progressive changes we must imagine to have taken place. On this fact most recent paleontologists seem to be agreed.

While the phenomena exist and must be reckoned with, the causes are by no means clear. Perhaps the continuous operation of some form of selection may be conceivably potent in some cases. But the more primitive types still retain their vigor and abundance, and this fact must not be overlooked in our explanation. It may be noted that these series, as usually recognized, are made up of genera, each genus a step in some definite direction, with numerous diverging steps at the same time. But there is no evidence that the organisms in question individually vary in any one determinate direction, or that the tide of heredity is swayed by the forces which make for orthogenesis. Most naturalists disclaim any teleological implications in the terms used to describe these phenomena as 'determinate variation.' It is sufficient that it would seem that the line of succession of genera is determined by unknown causes, causes other than those potent in producing the divergence of heredity which we call the origin of species.

We may perhaps find some clue to these matters in the phenomena of analogous variation. Like conditions produce analogous results on forms of very different origin. Osborn notes that nature has often a very limited range of responses to external conditions. In upwards of a dozen different groups of fishes of widely different relationships, nature has developed gar-like jaws. In several different groups (*Harriotta, Polyodon, Mitsukurina, Pegasus*), she has produced forms

with the upper jaw produced into a flat blade. In numerous unrelated groups of fishes, she has produced genera with the parrot's beak (*Scarus, Oplegnathus, Tetraodon*), or with an imitation of human incisors. In many different wholly unrelated groups she has developed bony plates, hardly to be distinguished superficially from those of her ancient ostracophores and dipnoans. Thus the earlier writers placed with the ganoids such forms as *Callichthys, Ostracion, Agonus, Pegasus, Hippocampus, Gasterosteus, Peristedion,* forms now known to have no affinities with the extinct mailed fishes, and for the most part no affinities with each other.

Such adaptive characters do not suggest relationship. They are mostly superficial only, and indicate not the origin or affinities of the forms possessing them, but rather the habits of the species in question, and the needs of their recent environment.

In finding what an animal really is, that is, in tracing its ancestry, we have in the words of Haeckel, mainly the three ancestral documents, morphology, embryology and paleontology. Adaptive characters are essentially external. The inside of an animal tells what it is, the outside where its ancestors have been. Perhaps a fuller understanding of orthogenesis will relate its facts to those of 'analogous variation' or the 'convergence of characters' in unrelated forms.

THE HUMAN SIDE OF THE INDIAN

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THE oneness of the American Indians with all races of men (including us whites) is readily admitted by those who have seen them in their human activities and not merely in their forced relations with so-called 'higher civilization.' The writer was fortunate enough, a number of years ago, to come into the friendliest contact with the Kootenay Indians of northern Idaho and southern British Columbia, one of the least spoiled aboriginal peoples of the continent, and brought back with him to the east many pleasant experiences and reminiscences of 'savage' life. Since that time the building of the Crow's Nest Pass railroad and the opening up of the Kootenay district consequent upon it have made impossible some of the incidents occurring during his visit as an investigator under the auspices of the British Association for the Advancement of Science.

The Kootenays are very fond of their children, the men much more so than is commonly believed, or even supposed. To see a man carrying a little child is by no means a rare sight. Among the Lower Kootenay in Idaho, the writer saw one of the older men of the tribe playing in right human fashion with his children. The little ones ran merrily all about him, pulling his hair, pinching him, etc. One little tot of some five years of age persisted in crawling all over him. He was very affectionate toward them and even allowed this child to put its toes into his mouth. Surely the white man could go no further!

About the same time, a young woman of fifteen was busy chopping firewood—and she handled the axe remarkably well. After carrying on her back to the tent the wood she had cut to pieces, she looked around for a little girl of five or six who was amusing herself at a distance. '*Tláne! tláne!* (Come! come!),' she cried loudly, but the child did not or would not hear. Soon she ran over to the child, caught her, spanked her and brought her home. The spanking was quite after the fashion of the whites, and was probably learned from them, as that method of punishment is un-Indian. The Kootenays seldom, if ever, whip their children, and one of them said that he would rather die than see a white man chastise his offspring. At one of the stores in the Upper Kootenay country a little Indian boy was playing 'hide-and-seek' with a little white girl as blithely as might be. This same little

fellow, whose skin seemed even dirtier than the shirt forming his only garment, was promised some candy if he would wash his face. Going to the river, a few yards off, he marched in, clothes and all, coming back dripping from head to foot, but beaming with smiles. The candy he ate in a way that would do credit to any white child. Not alone the children, but the adults as well, are very fond of candy, which they call *gāktlētl k'kōktsi,* or 'variegated sugar (sweetness).'

On another occasion, and at a different place, the writer had a little Indian boy to breakfast with him. After the first shyness was over, the little fellow conducted himself with a grace and dignity quite unknown to many white children of his age. And through it all his beautiful dark-brown eyes shone in the most captivating fashion.

At the Mission of St. Eugene, on the St. Mary's river a few miles from Ft. Steele, B. C., a school of a more or less industrial character had been established, and, at the time of the writer's visit, was attended by about sixteen girls and ten boys, a number of whom were of mixed blood, children of white men who had married Kootenay women. The school was conducted by members of one of the Catholic sisterhoods, under the superintendence of Father Coccolo, the resident missionary, who exerts a great and abiding influence over these Indians, who thoroughly appreciate his absolute devotion and self-sacrifice. The children, who were from seven to fifteen years of age, showed gratifying progress in their attempts to acquire some of the learning of the whites. Although they had been in attendance only a few months, some of them could already read from 'Sadler's Dominion Catholic First Reader,' and sang also, not very badly, 'God Save the Queen,' and 'Great and Glorious St. Patrick,' which seemed to be their *pièces de résistance.* Some could write a very fair hand—it is curious with what facility the Indian can often master this art as compared with his white brothers under similar circumstances. It should be mentioned in this connection that many of the Kootenays, as their drawings made for the writer indicate, have a good graphic sense. They can likewise draw maps and recognize on the maps of their country made by white men the chief topographical features. No extensive carvings on rocks or pictographic records have been reported from their country, however, the 'Painted Rocks,' on Lower Arrow Lake, being quite within the territory of the Salish Indians, and not belonging to the Kootenays. While in the Lower Kootenay country, the writer received from the daughter of David McLaughlin, from whom he collected many native texts of myths and legends, the Kootenay equivalent for 'God save the Queen,' which is presented here as a literary curiosity:

Gămnākōtlŏkōnĭqan
May he save
Yăkasinkĭnawăskĕ
He who made us

Gūwĭtlkā nāsūkwin pā́tlkē!
Great woman chief!

On a Sunday afternoon, which is the holiday of the week among those Indians more or less under the influence of the Roman Catholic missions, the Lower Kootenays indulge in horse-racing, or, more properly, horse-running, on the great grassy plains beside the Kootenay river. Their whole herd is collected in an open space near the camp and then driven in all directions over the prairie and through the bushes, chased by laughing and shouting Indians, armed with quirts, willow gads, etc. The horses are run down, tripped, lassooed, driven into the water. Some of the Indians took particular delight in driving the horses as close as possible, in full course, to the writer's tent, to his evident embarrassment, which they keenly enjoyed. As horse after horse thundered past, at very close quarters, shouts and peals of laughter would fill the air, accompanied by remarks in the native language provocative of still more amusement. While all this is going on, the children sport about in the bushes, or caper about in the plain, seemingly in imminent danger of life or limb. It is very interesting to see them chase one another with long whips, or try to lassoo each other. Often they attempt to run down or lassoo the colts or the tamer horses, and the skill some of them develop in so doing is really surprising.

Many of the Indians are quite fond of their horses and treat them better than do the white men. Some, however, use only too readily the spur and the heavy whip of the whites. The Indian Amelu, when out on the trail with the writer, even when the horses had no packs to carry, would walk them up and down the steep grades and was in other little ways 'merciful unto his beast.' In the Upper Kootenay country, an Indian was seen to beat cruelly with his whip the dog of a Chinaman, which had tried to bite the toe of his moccasin, after having been teased for a long time. Some of the younger Indians are rather companionable with their horses, and it is worth noting that they have coined a few slang words, such as *k'ādla,* instead of *k'kātlahā́atltsin,* 'horse,' and *mistak'ādla,* 'colt.' The Kootenay name of the horse bears witness to its exotic origin, for it signifies literally 'elk-dog,' these Indians having had recourse to the aspect of these two animals already familiar to them, in order to assign a name to the new creature, the horse, introduced by the neighboring Indians directly or indirectly through the whites. Other animals not originally natives of the Indian country have sometimes very interesting names. Thus, the cow is 'the variegated horned animal'; the pig, 'the cut-off nosed'; the mule, 'the big ear'; the hen 'the variegated tail,' or 'the spotted tail,' or, again, 'the prominent tail'—these names applying particularly to the 'rooster.' Some of the names of plants new to the Kootenays

and introduced through the whites are: Cabbage, 'edible leaf plant'; cucumber, 'plant that grows on the ground wild'; oats, 'horses' food'; orange, 'big rose-hip' (the apricot, peach, pear, tomato, apple, are all named after the hip of the prairie-rose). The daughter of David McLaughlin, of the Lower Kootenay, a *métis*, who spoke only Kootenay, coined for the writer a new word on the spot. This was a name for the sunflower, which she called *kākādlimūkōwādlidl'yit*, which seems to be derived from the word for 'light.' The Indian Amelu was not nearly so ready to assign names to new things—it is probably true that women exceed men in this respect among some primitive races. When asked to name a strange plant Amelu would often reply simply, *nōtlūkinē*, 'it is strange (foreign, unknown),' or *tsâkō nána*, 'it is small (a little thing),' or, again, *hòk·ā ōphanē*, 'I don't know.' Still Amelu did know a great many things, for one evening he reeled off 91 names of birds. On other occasions he had named over 100 species of plants, shrubs and trees, besides a large number of animals, fish, etc. Of every one of all these he was able to give brief descriptions.

When a scientific investigator first makes his appearance among a primitive people, it is often difficult to convince them that his advent is not connected with the attempts of white men to steal their land or ill use their women—these are the two chief sins laid to the charge of the 'superior' race. The writer once by accident intruded on what might be called the meeting of the 'sewing circle' of the Kootenays, but the shouts of the women immediately reminded him of breach of primitive etiquette he was committing by peering into the women's tent. One of the chief men of the Upper Kootenays, who was unfriendly to the writer's objects, resurrected a dead-letter law of the tribe by which the women were forbidden to talk English with the white men. When the writer overcame this difficulty by using the Chinook jargon, the same man used his influence to have the women forbidden to talk anything but Kootenay, but by that time he had learned enough Kootenay to make this prohibition of not much avail. Some of the Indians understood very readily the idea of having their language and their legends preserved by means of the white man's records, and took the utmost pains to secure accuracy and completeness. Amelu was so interested in the matter that he suggested a new method of procedure, *viz.*, that the writer, if he really wanted to make the best possible investigations and record everything, should marry the niece of the old chief, who was about to resign office—the inheritance was in the female line—and thus become chief of the tribe, when he would be able to accomplish his heart's desire in the way of scientific knowledge. The ties of his own people, naturally, prevented this consummation, which certainly would have had its advantages for science, for as chief of the Lower Kootenays the writer might have accomplished much.

The reactions of the Kootenays to the proposal to have their stature, etc., determined were often very interesting. Most of them at first refused altogether, and their prejudices were very difficult to overcome. One Indian told the writer that he could measure him when dead, and another said that he was not a child—others, however, were very unwilling that their children, in particular, should be measured. To measure the women, was, of course, except in rare instances, impossible.

With the language it was different. The Indians would often come to the writer, without having been asked, and inform him that they had some words which they wanted him to put in his 'book' of their language, so eager, apparently, were some of them to help in the preservation of their speech. This is a rather common experience with those who have come into sympathetic relations with savage and barbarous peoples. Amelu, after he had told the writer a great many things about himself and his people, would sometimes turn round and catechize his catechizer, asking him all manner of questions about the whites, their manners and customs, etc., showing great interest, and being sometimes much amused. 'What do you call this in your language?' he would often ask, as he came across something new or interesting. 'Haven't you white people any stories about Coyote?' he would say, after relating some of the Kootenay legends. Once, when an Indian was asked to tell the story of the sun and moon, he began to give a version of the Bible account of the creation, as he had it, probably from some priest. He appeared surprised when the writer informed him that that was the story of his people, and after a little while admitted that it wasn't Indian, and began to tell the Kootenay story of how the coyote and the chicken hawk made the sun and moon. Amelu, who was an Indian under mission influence, did not hesitate to shoot a chicken-hawk for the writer, although that bird is one of the chief figures in Kootenay mythology—he had more fear of 'medicine-men' than he had superstitious views of mythological personages. He would not eat meat on Friday, but would eat the 'saw-bill' duck, which, he declared, ate so much fish that it was practically fish itself. Another 'religious' practise of his was wearing the old Indian breech-clout, even when he had adopted the trousers of the whites. In a few other respects also he was a curious mixture of the old and the new.

The Indians are very prompt to notice any personal peculiarities or idiosyncrasies of speech, action, movement, etc. In climbing into the saddle the Kootenays swing off the right foot, and not off the left, as does the white man. The fact that the writer (amateur in his horsemanship) happened to climb into the saddle 'off-side,' as we say, gained him at once the name, 'The man who rides like an Indian.' This circumstance was a road to the favor of these people, who are always delighted to have one do instinctively as they do. The mastery of the

difficult *k* and *tl* sounds, so characteristic of the Kootenay language, is also much appreciated by the Indians. This will be easily understood when one learns that, in the mouths of the whites the word for 'horse,' *k'kātlahaatltsin,* is made over into kallahalshin, or worse, while the distinction between words of entirely different significations, *e. g., g· ūstet,* 'trout,' and *k· 'ūstit,* 'tamarack,' is altogether ignored. His attention to these points caused the Indian to dub him 'The man who talks straight.' A third name conferred upon him recorded the fact that he never lied to them. In another the Indians called attention to his very dark hair, 'The man with hair like an Indian'—the possession of which was another bond of union with them. A fifth, and more formidable name, 'He uses the long stick'—he owed to the anthropometric apparatus which he carried with him. By use of these various names the coming and going of the writer was heralded all over the Indian country and the natives soon came to know him well and understand the reason of his presence among them. Some of the white settlers have also received interesting nicknames, one prominent individual, who had a glass eye, being termed 'The man who takes out his eye,' and the Indians are clever in their imitation of his manipulation of it.

To hear a white man blundering along in his efforts to speak Kootenay correctly is one of the best quarter-hours the Indians ever enjoy. Even the wives and children of white men who have married squaws extract considerable amusement out of the linguistic mistakes of their husbands and fathers. Any one who believes that the Indian never laughs will be heartily undeceived after a session of this sort. The inability of the whites to master the numerous gutturals with which the Kootenay language is provided is a never-ending source of laughter. The Indians went off into roars of merriment over such mistakes as saying *inisin* (horsefly) for *inisimin* (rainbow); *k'ūpi* (owl) for *k'ūpōk* (woodpecker); *hāhās* (skunk) for *hāhā* (crow), etc. When some one said for *kānkūptsē* (bread baked in a pan), the perfectly unmeaning *tankūptsē,* it reminded the Indians of a real word, *t'ānkūts* (grouse), and they indulged in a fit of laughter. When the writer mispronounced the word *g· ūstet* (trout), on one occasion, an Indian went off into the woods near by and returned with a diminutive 'tamarack,' the name of which is in Kootenay *k· 'ūstit,* pronouncing that word correctly, as he handed him the shrub. The writer's desire, which the Indians fully comprehended, to obtain a large vocabulary and a considerable body of texts of myths and stories in the native language led naturally enough to the very embarrassing demand that he should read every word and every sentence over and over again until he could repeat them all without the slightest error—this was worse than the child's well-known demand for the repetition of its favorite

stories without any deviation from the original text, since he could often write down the word correctly, when he could hardly satisfy the Indian's requirement in the way of pronunciation.

The Indians have their 'chatter' and 'nonsense' as well as the whites. Amelu was very fond of chanting and talking to himself in somewhat waggish fashion. This he called, in the Chinook jargon, 'cultus wawa' (nonsense). As he sped along the trail he would sing to his horse, slapping it on the flanks, or making rhythmic motions with his hands:

Tō tō tō tō!
Tum tum tum tum!
Tā tā tā tā
Tai tai tai tai!

The repetition was *ad libitum*, according to his mood, or his fancy. Another refrain, which had an 'infinite variety' of inflection, intonation, etc., was the following, which he sang with great animation:

Hai yā! hā hē yau!
Ē yā! hā hā hai yau!
Hē yā! hō yō!

This sounds a good deal like some of the refrains used in the gambling games of the Kootenays. Another refrain, which he chanted as the fire was being spoiled by the scattering of the burning logs, was:

Hum kē pupum!
Hum kẹ̄ pupum!

An interesting procedure, indulged in often by Amelu, was the mispronunciation and distortion of words, amounting not seldom to real punning. Thus for *saiwáskō*, the name of a species of dragon-fly, he would repeat: *Saiwásukw', sauwátskō, sauwásko, saiwásekō, saiwátshkō*, etc. Sometimes when the Indians were telling legends in their own language, they would deliberately mispronounce or distort words to see if the writer noticed the difference—if he did not at the time they would generally tell him, and have a little fun over it. When they came to the parts of the stories where the animals played tricks on one another they would stop to laugh over it, making fun of those who couldn't talk very well. The Indians would laugh to themselves when the writer used a proper Kootenay term, and one of the other white men about a slang or jargon term without knowing it.

While the writer and Amelu were out botanizing and sampling every edible berry (the Indian, of course, tasting first), they ran across the 'soap-berry' (*Shephardia canadensis*), the *gōpātētl* of the Kootenays. The wry faces made by him as he chewed up a few of the

berries, greatly amused his guide, who explained that the Kootenays did not like these berries half as well as did the Shuswap Indians, for they 'tasted like bad whiskey.' It may be said here that the Kootenays have many names, but little use for whiskey, both on account of their own inclination against it, and by reason of the stringent laws and the good influence of the Catholic missionaries—the miners also, as a mere matter of self-defense, aid in the thorough enforcement of the law. The story is told of a Kootenay who, when sick, was told by a priest to take a little whiskey as medicine. He sturdily refused, with the emphatic declaration: 'You say whiskey bad. Bad one time, bad all time.' Poetic justice was satisfied by the recovery of the patient. The Indians are very skilful in their mimicry of the drunken white man. Among the Kootenay names for whiskey are the following: *wūō* (water, liquor), *sūyăpi wūō* (white man's water), *nipik· ā wūō* (spirit water), *nōtlūkinē wūō* (strange, foreign water).

After the tasting of the berries was over, Amelu took pleasure in crushing some of them between the palms of his hands and showing how 'soap' could be made. The leaves of the shrub he then used as a very primitive towel. Other experiences of the writer on this excursion convinced him that the Kootenays are not without a sense of humor. On the Mooyai trail the writer ran into a group of nettles, and Amelu hugely enjoyed his surprise at being stung.

This humorous reaction to the surprise, embarrassment, awkward predicament, accidental discomfiture, etc., of a fellow man is common among these Indians, both with reference to their own tribesmen and to individuals of other races, such as whites and Chinese, with whom they come into contact. In the region of the Columbia lakes, there are a cold spring and a warm spring (not steaming so as to be noticed) close beside each other, and a common trick of the Indians is to induce an unsuspecting stranger (red or white) to step into one immediately after the other. The writer, upon the suggestion of Amelu, once took a plunge in the Kootenay at Ft. Steele, but did not stay in more than a moment. The water was almost icy cold, as the Indian knew, by his own confession, and the haste with which his white friend got out of the water stirred deeply his sense of the ridiculous. Similarly, whenever the Indian horse threw him off into the pine-brush or cast him over its head into a creek, his guide would feel bound to laugh more or less heartily. Another fertile source of amusement was the embarrassment caused the writer by his first acquaintance with the snapping and snarling, no less than thieving, Indian dogs, who were the pest of the camp. One of these curs actually seized hold of a can of corned beef and was running off with it, when the use of another can as a missile caused him to give up his plunder. This action must have seemed very funny to Amelu.

This sense of humor is collective as well as individual. The writer was present beside the camp-fire one night, when one of the Indians was giving, for his benefit, an account of a government official who had recently 'inspected' the Canadian Kootenays. This individual was said to have insisted on taking with him all the appurtenances and conveniences of civilization, including a cook-stove, a feather bed, etc., and the group of listeners expressed loudly their merriment, as the speaker touched off the white man's peculiarities. The Indians were fully conscious of the fact that another official (likewise another white man, a storekeeper) was really very much afraid of them. They made this known to the writer in sarcastically humorous fashion. Indeed, the white settlers hardly are aware how much the Indians comment upon their appearance, their character and their actions, especially in a quasi-humorous way. One Indian actually told the writer, with 'fun' in his eye, however, the order in which the white people would be killed off, should trouble ever occur—a certain settler, who could see nothing good in the Indians, was to be the first victim, and the writer (if he had to be included) was to be the last.

The Kootenays take delight in playing tricks, not only upon one another, but also upon the whites. The writer had complained of the first horse procured from them as being altogether too fast for his liking and too 'wild,' so the next time he asked for a horse he was given a creature, which, except when he was in the company of other Indian horses, went at less than the proverbial snail's pace. The writer's indignant remonstrances evoked abundant mirth on the part of the 'guileless' natives. While measuring an Indian in the Lower Kootenay country, he had an experience of a more startling sort. The Indian suddenly rose to his full height, and, quickly drawing his knife from its sheath, pretended to strike him—the writer being soon reassured, however, by the loud laughter of the other natives about him. Tricks like this are much enjoyed by them.

In the mining regions of the Kootenay country, there are a considerable number of Chinese, who have taken up the claims abandoned by the whites, and manage to make a good living from them. The superior attitude assumed toward these people by the whites has its effect in the way the Indians look upon them. As a rule the Kootenays and the Chinese get along well together, but the former sometimes hector and bully the latter, and not infrequently Indians become semi-parasitic, doing odd jobs for the Chinese, or imposing upon their charity. Many of the Indians regard the Chinese as quite inferior beings, and the poor Celestials seem in more or less awe of them. In jesting fashion, the Indians will call the Chinese 'brothers' or 'cousins,' but persistently deny any close relationship. One of the Kootenays, who knew that the whites thought the Chinese and In-

dians looked alike, pointed out to the writer several differences between them of a physical character, and then remarked, in the Chinook jargon, 'halo siwash'—not Indian. The single braid, or 'pig-tail' of the Chinese is a matter of sport for the Indians who usually wear their hair free, or in several braids. The Kootenay name for Chinaman is *Gōōktlām,* or 'tail head,' in reference to the hair-braid. The Indians also make fun of the alleged use by the Chinese of cats as an article of food. One of the Chinese of Wild Horse Creek, a certain Lam Kin, acted as 'doctor' for some of the Ft. Steele Indians, his cure being a sort of medical tattooing, known by the Indians as *katlku,* which many of them affected after their own ancient shamanism had been more or less abolished through missionary influence.

One afternoon, when camped in the Lower Kootenay country, the writer thought he detected the presence of a skunk in the vicinity of the tent. He saw his Indian guide some distance away and hailed him about it. Only a non-committal answer was obtained. Noticing that the Indian did not venture to come near, he asked him what he had been doing, and started to go toward him, when he soon perceived what was the matter. Amelu had been trying to kill a skunk, and his scanty raiment exhaled abundant evidence of the encounter. He was given some money to get new clothes at the little store not very far off, and soon returned in triumph, having taken a bath in the river on the way back. How he induced the storekeeper to let him get near enough to purchase what he wanted he did not say, but perhaps the exchange was effected after the primitive fashion sometimes indulged in by children. However that may be, Amelu was a thoroughly shamefaced red-skin, as he stood off at a distance, afraid to come near the tent until the cause of his embarrassment had been disclosed. It appears that the Chinese in the mining districts of the Kootenay use certain parts of this animal for medicinal purposes, and the Indians catch them and sell them. Some of the Kootenays are said to catch skunks with their naked hands—usually they knock them over with sticks or stones. In capturing these and other small animals they take pleasure in getting as close to them as possible before striking. When using the writer's gun, Amelu would creep up so close to the grouse, known locally as 'fool hens,' that they would be blown to pieces when he did discharge his weapon. He also appeared to take great delight in 'gaffing' fish as compared with catching them with hook and line, although he enjoyed that very much, especially when he became aware of the writer's inexpertness as a fisherman.

Past one of the camping-places on the Kootenay river a steamer used to go every few days, and Amelu, from the moment he first heard the whistle till the vessel disappeared from his sight, would stand upon the bank waiting for it, gazing at it, peering after it. The sound of

the whistle never failed to arouse him, or to call him forth, wherever he might be, and the steamboat was, doubtless, one of the wonders of his life. When a trip up the river, from the international boundary to the settlements on Kootenay lake, was proposed, he was beside himself with joy and anticipation. He became excited beyond all bounds, and when the whistle sounded danced with delight and capered about, not exactly like a gazelle, for he weighed 177 pounds and was heavily built. When he got on board and could examine things at his leisure, he was 'tickled to death.' He inspected everything that was at all accessible, watched the motion of the vessel and the revolutions of the wheel, listened to the noise of the engine and the hissing of the steam, gazed in rapt wonder at a score of different things that from time to time riveted his attention. But his keenest delight, after all, was when he could signal or shout to some of his tribe on the banks or in canoes in the stream. The relish with which he did this was unmistakable. And, on the journey back, he was quite as elated, if not so inquisitive. Certainly that trip on the 'fire canoe' was one of the events of his life.

The 'fire canoe' seems to have appeared more natural to the Indians than the locomotive, or 'fire wagon,' possibly because of its progress in the water, like a canoe, and not over the land with the 'fearful eye' of the latter, which so impresses many primitive peoples. In northern Idaho the Indians were very much frightened by the first steam trains. When the railroad was near Rathdrum, several Lower Kootenays, who had been sent into that part of the country to deliver some letters, were so affected by the sight of the puffing, snorting, fire-spouting locomotive that they threw down their letters on the spot, turned about and fled for dear life, not daring to look back once until they were safe again with their own people. They reported that they had been chased by the 'Evil One,' himself, and had escaped with the greatest difficulty. Later on, as happens with other peoples, familiarity bred contempt, and the Indians can now look at these creations of the white man's genius with much less of fear than of wonder or of interest. The Kootenay youth is more afraid of doing 'woman's work' than he is of the 'fire-wagon.' This was the case with Amelu, the writer's guide, who was with difficulty persuaded to make his own pan-bread on the trail. He was '*hiyu* shame' (much ashamed), and used to make it always before an Indian camp was reached. In other things also, he shared the disinclination of his fellow tribesmen to perform any labor that properly belonged to women, according to the customs of his people.

Some writers would deny to the American Indian all possession of romantic love, or of love in any very high sense of the term. This, of course, is an utterly untenable theory, as any one who has seen the Indian at home well knows. The writer's 'guide, philosopher and

friend,' Amelu, a young man of 22 years, was in love all the time he was with him, and gave expression to many of the orthodox symptoms of that state in an undoubted fashion. The shamefaced way in which he would answer when asked why he had been away from the tent (in the neighborhood of an Indian encampment) so long the night before was a convincing fact. One evening he asked for a little money, and no amount of coaxing would for a long time induce him to say what he wanted it for. At last, however, in real lover fashion, he admitted that he wanted to buy some article or other to take to his lady friend, who was to put the finishing touches upon it. On this occasion Amelu blushed as much as the redskin can, and that is a good deal. Altogether, as an eminent Americanist once said, the Indian is a man, even as we are men. This the writer knows by actual experience, from the moment of his first arrival among the Kootenays, when *halo naika cumtux* (Chinook jargon for 'I don't know') was the only conversation on their part, to the time when he sat with them, round the campfire and himself began the story-telling: *Kānáqē Skínkūts,* 'The Coyote was going along.'

THE FRESH-WATER FISHES OF SOUTH AND MIDDLE AMERICA

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A. The salient features of the fish fauna of the Americas south of the United States are:

1. Great variety of fish life in the area between the Caribbean Sea and the Argentine Republic.

2. Paucity of 'types' or families contributing to this variety.

3. Paucity of the middle American fauna and its essentially South American character except for

4. the isolation of the fauna of the Mexican plateau.

5. Paucity of the Pacific slope fauna and its essentially Atlantic slope character.

6. The 'marine' character of the Titicacan fauna.

7. The paucity of the Patagonian fauna and its essential difference from the Brazilian fauna.

8. The similarity of the tropical American to the tropical African fauna.

The first fresh-water fishes of South America were described by Marcgrav in 1648. Additional accounts were given by Gronow, 1754 to 1756; Scopoli, 1777; Bloch, 1794; Lacépède, 1802; Bloch and Schneider, 1807; Cuvier, 1817 to 1818.

In 1817 the king of Bavaria sent Spix and Martius on an extended trip to Brazil. Spix was working at the report on the fishes when he died. The collection was turned over by Martius to Louis Agassiz, a student of twenty-one at Munich. It had been nip and tuck between Agassiz's desire to study natural history and his father's desire to have his son study medicine. The commission to work up the Brazilian fishes was surreptitiously undertaken by Agassiz and the results published in a superb folio volume. This work, which tinctured the entire later life of Louis Agassiz, was by far the most important contribution to the fresh-water fishes of South America that had appeared. Agassiz's desire to visit Brazil himself was not fulfilled until forty years later, when, as the head of the Thayer expedition, he spent sixteen months in Brazil with twelve assistants, devoting his time mainly to fresh-water fishes.

I was a student under Jordan when Mrs. Agassiz's 'Life and Letters of Louis Agassiz' appeared in 1885. Agassiz's account of his expedition to South America, coupled with the statement of Jordan that no

SOUTH AMERICA—the hypothetical line of demarcation between the Patagonian and Tropical American fauna marked – – –. Centers of distribution in unbroken circles, and hypothetical lines of migration by arrows.

comprehensive account of his collections had ever been prepared, created the desire to examine this lavishly rich fauna. In the fall of 1887, with Mrs. R. S. Eigenmann, I began work on Agassiz's unrivaled collections, to which I had gained access through the courtesy of Mr. Alexander Agassiz, the director of the Museum of Comparative Zoology, and Mr. S. Garman, the curator of fishes. Financial and other reasons

compelled me to abandon the work when but half finished. Occasional collections received from South America for identification have, however, kept up my interest. The entire problem presented by this fauna has been reviewed and will be published in one of the reports of the Hatcher expedition to Patagonia. I am permitted to publish this summary of results through the courtesy of the editor of the Hatcher volumes, Professor W. B. Scott, of Princeton University.

1. *Variety of Fish Life.*

On February 23, 1866, Louis Agassiz wrote to the emperor of Brazil:

> I estimate the total number of species which I actually possess [from the Amazon] at eighteen hundred, and it may be two thousand.

To this is added a footnote in Agassiz's 'A Journey in Brazil,' p. 383.

> To-day I can not give a more precise account of the final results of my survey. Though all my collections are safely stored in the museum, every practical zoologist understands that a critical examination of more than eighty thousand specimens can not be made in less than several years.

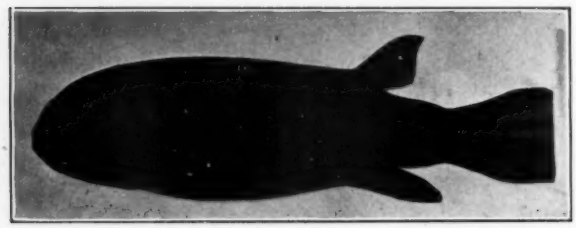
Agassiz secured more species from a small lake in the valley of the Amazon than there are in all the fresh waters of Europe.

The number of species he collected was overestimated by Agassiz. While about half of his Amazonian collections have not, after forty years, been examined, it is certain that the species not yet examined will not swell his list to 1,800 species. The total number of species recorded from the Amazon basin up to date is 674.

Although Agassiz's estimate of the number of species he collected is too high, the total number of species found in South America is very great. About ten per cent. of all the known species of fishes have been recorded from the freshwaters of South America. In 1892 I estimated that three fourths of the fauna was known. Now, after examining recent lists, and considering that collections have largely been made in easily accessible and great highways, and that from great river basins like the Purus, Tapajos, Xingu and the Uruguay and the greater part of the Madeira and the Tocantins we have nothing at all, and that even from the great Orinoco and Magdalena we know next to nothing; I doubt very much if we even yet know so much as three fourths of the fauna of the area between the Caribbean Sea and the Argentine Republic.

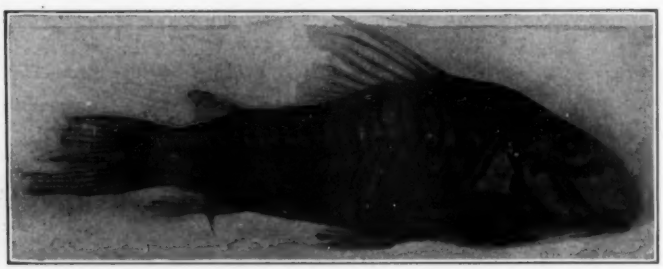
The tropical American fresh-water fauna, having its center of greatest diversity in the middle Amazon basin, is attenuated northward till it reaches the vanishing point just on the borders of the United States. Southward it extends to somewhere—no one knows where—south of Buenos Aires. The Patagonian fauna and North American fauna are entirely different from the tropical American fauna and from each other.

The key to the great diversity of the tropical American fauna is to be found in the enormous single water system, extending from 10°



1. *Calomesus psittacus* (Bloch & Schneider) a Marine Type widely distributed in the Rivers.

Hatcheria, a Mountain Catfish. Relatives of this Species Range from Venezuela to Patagonia.



3. A *Corydoras*, an Armored Relative of the Catfish

4. *Pimelodella gracilis* Val., One of the Smaller Catfishes about Natural Size.

north to 35° south latitude, and from 50° to 79° west longitude, providing a continuous north and south waterway of more than three thousand miles, and an east and west course of over two thousand miles, and embracing the Orinoco basin, the Amazon basin and the La Plata basin, draining over 3,000,000 square miles of territory, or an area about equal to that of the United States, exclusive of appendages.

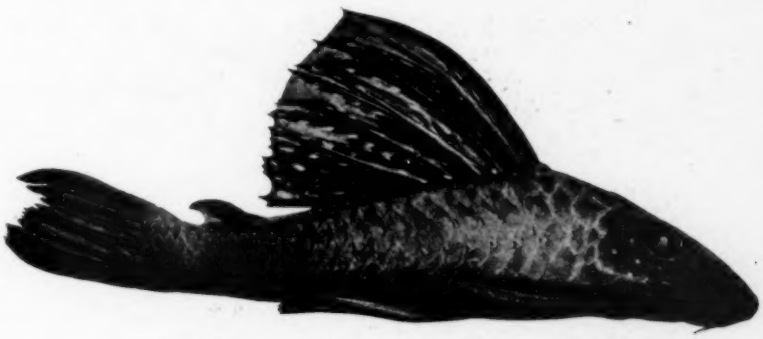
2. *Paucity of Types.*

There are found in the rivers of South America representatives of many marine fishes. Soles, swellfish, stingrays, needlefishes, mullets,

sciænoids and the herring tribe give to the South American fauna a peculiarly marine flavor. But all these form but a small fraction of the entire fauna, and their elimination would make little inroad on the number of species. All are recent additions from the sea.

There are also in South America a number of undoubted relicts of former times, and if one should judge by the interest excited by the genera *Synbranchus, Lepidosiren, Arapaima* and *Osteoglossum,* it would seem that these genera formed an important element in the present fauna; but they are so few in number that they also might be eliminated without any appreciable depreciation in the variety of the South American fauna.

After eliminating these, then, we come to the reigning element in the present fauna, the element now in its prime and best suited to contribute to the elucidation of the methods and paths of divergent



5. *Doras dorsalis* C. & V., AN ENCRUSTED CATFISH.

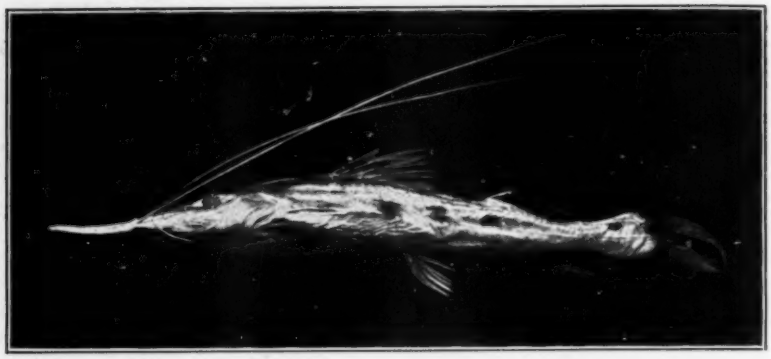
and convergent evolution and the paths of dispersal. Chief of these elements is the superorder Ostaryphysiæ, composed of the Characinidæ with about 500 species; the Gymnotidæ with about 30 species, and the various families of catfishes with about 500 species. Pœciliidæ, dominant in middle America, contributed materially to the fauna—about 45 species.

The largest contribution, aside from the characins and the catfishes, is furnished by the Cichlidæ, with about 145 species, in south and middle America.

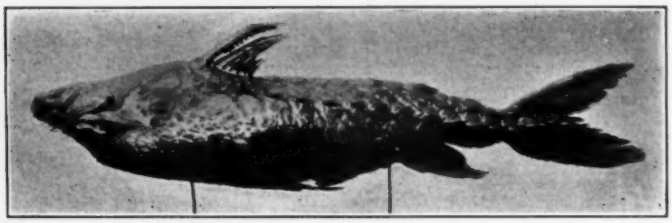
The great variety of South American fishes is due to the divergence in the types of characin, catfish, cichlid and pœcilid.

3. *Paucity of Middle American Fauna.*

The fresh-water fauna of middle America is poor. No river excepting the Lerma harbors as many as 50 species. The genera south of the isthmus of Tehuantepec are practically all South American with the addition of pœcilids.



6. *Platystomatichthys sturio* KNER. ONE OF THE GIANT CATFISHES.



7. A NEW *Plecostomus*, ONE OF THE MAILED CATFISHES.

8. A *Farlowella*. ONE OF THE SLENDEREST OF THE MAILED CATFISHES.

4. *The Isolation of the Fauna of the Mexican Plateau.*

The Lerma, draining the Mexican plateau, harbors an old fauna. Only three of its fifty-four species have been taken in any other river basin. Eight of its twenty-one genera are peculiar to it.

5. *Paucity of the Pacific Slope Fauna.*

From the Pacific slope of South America, south of Panama and north of Chile, but 55 species of fresh-water fishes have been reported. This condition is not unlike the condition in North America, for more species may be obtained from a single favorable brook in the Mississippi valley than are found on our entire Pacific slope, from San Diego to Alaska.

Fifteen out of the 55 species are also found on the Atlantic slope, and the others, with three exceptions, belong to genera of wide distribution on the Atlantic slope. None of the species would cause any surprise if found on the Atlantic slope.

6. *The Marine Character of the Titicacan Fauna.*

The fish fauna of Lake Titicaca, about as large as Lake Erie, consists of a catfish, *Pygidium rivulatum*, and several species of *Orestias*, a *Fundulus*-like pœcilid. The former belongs to a genus of mountain catfishes universally distributed in mountain streams of South America. It has succeeded in crossing all sorts of barriers, and has undoubtedly migrated into Lake Titicaca from the streams surrounding it. The genus *Orestias*, on the other hand, is confined to Lake Titicaca and the streams and lakes immediately surrounding it. The latter have doubtless received theirs from Lake Titicaca, which, on its part, could only have received them at the time it was an arm of the sea, in which its nearest relatives flourish.

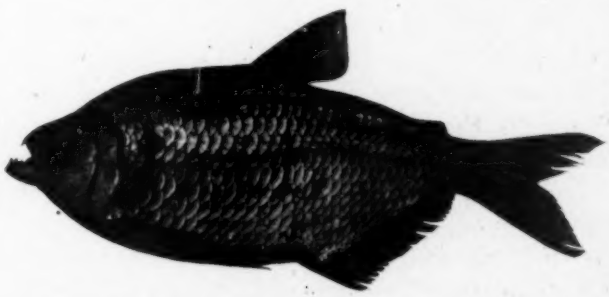
7. *The Patagonian Fauna.*

The interest in the Patagonian fresh-water fish fauna is entirely out of proportion to its diversity and centers largely in its origin. Only about twenty-five species of fishes are known to live or enter the fresh waters south of the line joining Valparaiso and Bahia Blanca. These few species fall, according to their origin, into four distinct groups.

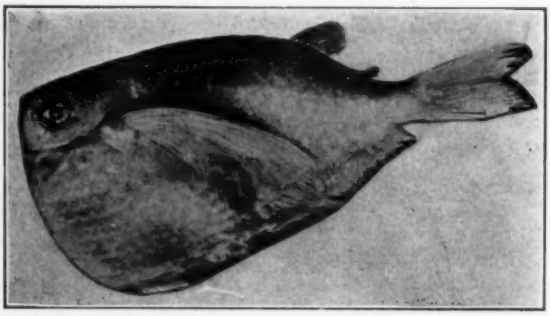
1. Immigrants from the sea (*a*) are in the process of acclimatization (species of *Menidia* and *Atherinichthys*), or (*b*) may be looked upon as long established (species of *Percichthys* and *Percilia*). Members of (*a*) are found in all the rivers; members of (*b*) are found in the north chiefly, but reach the Santa Cruz.

2. Immigrants from the fresh waters on the north; a very small overflow from the extremely rich fauna to the north and still retaining their generic affinity with the northern forms. Here belong the species of the genera *Cheirodon* and *Astyanax*, which are very widely distributed in tropical South America and are not known to extend much south of the Rio Negro.

3. Autochthons or of doubtful origin. Here belongs the highly



9. *Astyanax bimaculatus* L. A CHARACIN FOUND EVERYWHERE IN TROPICAL SOUTH AMERICA, from Panama to Buenos Ayres east of the Andes, close relatives existed in the early tertiary. This photograph of a specimen from Trinidad.*



10. *Gasteropelecus stellatus* KNER, AN EXTREMELY SWELL CHARACIN. This is connected by many intermediate forms with normal-shaped species.

interesting *Diplomyste,* which is found on the northern border of Patagonia, but is not a derivative of the tropical American fauna. It is a relict of the original catfishes, in which the maxillary is still functional as a tooth bearer. Here belongs also *Nematogenys,* a catfish related to *Pygidium.* Like the members of group 2, these species are confined to the northern fringe of the Patagonian area.

4. There remain unaccounted for the members of the Aplochitonidæ, Galaxiidæ and Petromyzontidæ, chiefly of southern Patagonia.

Of the Aplochitonidæ there are two genera, *Aplochiton,* with an undetermined number of species in the Patagonian region, and *Prototroctes,* with three species, one in Queensland, one in South Australia and one in New Zealand.

Of the Galaxiidæ there are two genera, *Neochanna* (*apoda*) from New Zealand, where it frequently burrows in damp clay away from water, and *Galaxias,* with about 30 species, from New Zealand, New South Wales, South Australia, Tasmania, Cape of Good Hope, southern South America and the Falkland Islands. The Petromyzontidæ are found in all temperate fresh waters and seas in both the northern and southern hemispheres.

The distribution of the two former families is of interest in connection with the theory of a former antarctic continent connecting the land masses in which they are found. In favor of a former land connection it may be argued, and with justice, that while these species descend to the sea, the probability that any pair of individuals should migrate from Cape Horn to New Zealand, or *vice versa,* is highly improbable. (This objection loses some weight if they spawn in the sea, as is reported.) There are no intermediate places that might be colonized and serve as new centers of distribution. It may further be urged that these species could readily have been distributed to their present homes by migration from stream to stream along a continuous coast line or on a land-wave moving from one place to another. An obvious objection comes from the paucity of the forms with this peculiar dis-

tribution. If there was a continental mass connecting South America with New Zealand and Australia fit to be inhabited by fishes, there must have been an abundant and diverse fish fauna which has disappeared. If the antarctic continent depended entirely for its existence on the evidence from the distribution of the fresh-water fishes, its existence would be very highly theoretical and precarious.

However, the evidence from other sources of a former land connection has become conclusive, and I am of the opinion that during the submergence of large parts of Patagonia during the late Pliocene the formerly abundant fresh-water fauna became exterminated, with the exception of those that were indifferently fresh-water or marine.

The Petromyzontidæ offer still another difficulty. There is no place on the American continents between the Mexican plateau and Central Chile that harbors any species of the family. The northern and southern species belong to distinct genera. At least two of the South American genera are peculiar while two others are found in Australia and New Zealand.

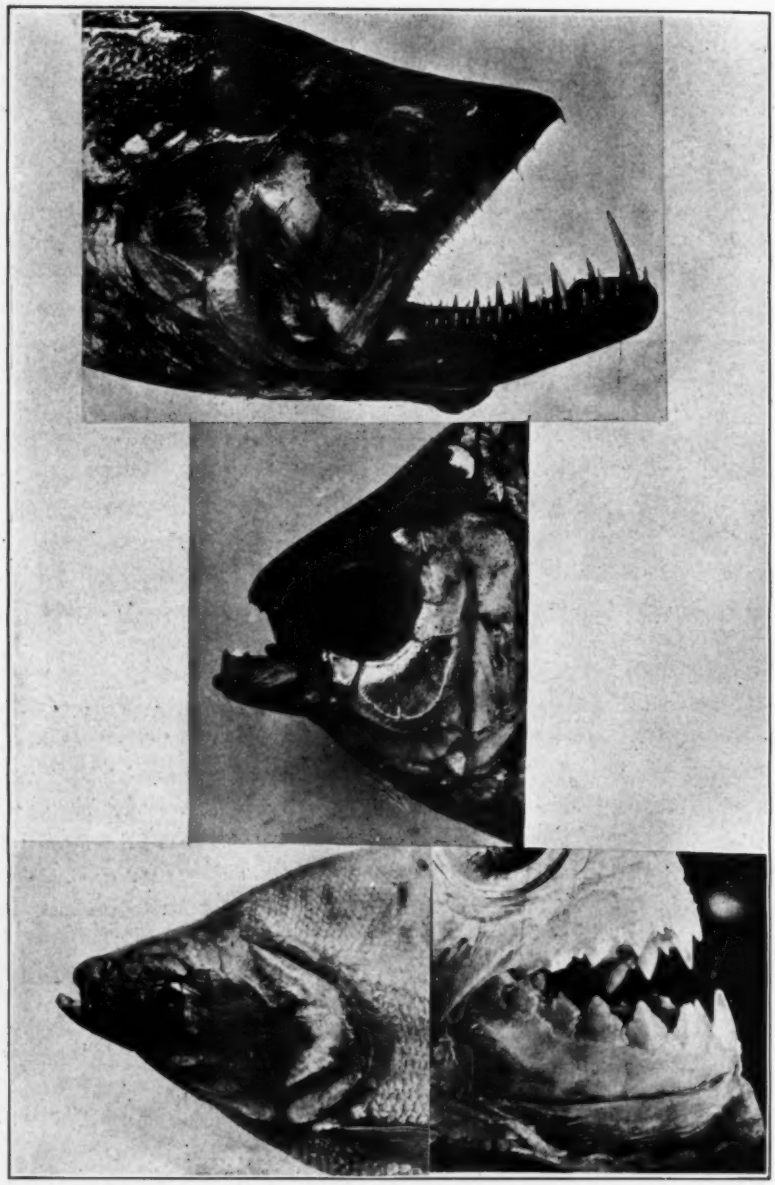
8. *The Similarity of the Tropical American to the Tropical African Fauna and the Necessity of and Evidence for a Former Land Connection between Africa and South America.*

North America has not contributed a single element to the fresh-water fish fauna of South America. Two prominent South American families, the Characinidæ and the Cichlidæ, have representatives as far north as the Rio Grande basin, and one of these has succeeded in crossing over into Cuba, evidently from Yucatan; on the other hand, several members of the North American fauna have representatives as far south as the Isthmus of Tehuantepec. The North American fauna is entirely distinct from the tropical American fauna.

But four genera of fresh-water fishes of South America north of Patagonia are found in any other continent than North America. These are *Synbranchus, Agonostomus, Cotylopus* and *Fundulus*. The first found also in brackish water, the second belonging to the marine family, Mugilidæ, and the others to the Pœciliidæ. *Synbranchus* is found in India, *Agonostomus* in middle America, the West Indies, northern South America and New Zealand, Australia, Celebes, Mauritius and Comoro Islands. There is no reason why *Agonostomus* may not have been independently evolved in the South Sea and in America from marine Mugilids. *Cotylopus* is found in Central America and Reunion and *Fundulus* in America and Europe.

It is possible that *Pimelodus* is found in Africa and *Pseudauchenipterus* in Madagascar. Both are found in South America.

Africa and South America have two groups of families in common. The first group comprises the Serranidæ, Sciænidæ, Mugilidæ and Tetraodontidæ.



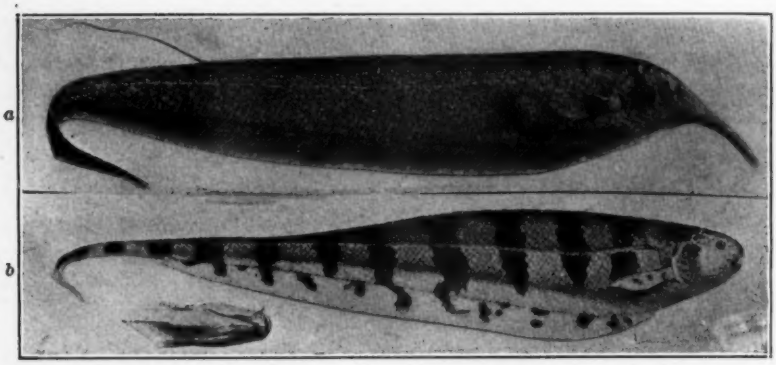
11. Adaptive Radiation in the Characinidæ. The central figure of *Astyanax bimaculatus* with notched teeth probably represents the more primitive condition. The lower left-hand figure represents *Anodus latior* with no teeth and a very long alimentary canal, a mud eater. The lower right-hand figure represents the scissor-like jaw and teeth of *Serrasalmo humeralis* whose relatives have been repeatedly reported to have killed bathers before they could reach shore after being attacked. The upper figure represents *Raphiodon vulpinus* Spix which has reached the extreme in conical teeth, the large canines protruding above when the jaws are closed. The over 100 South American genera and 500 species of this family offer pretty complete series from the center to the extremes with many lateral branches.

These are all marine families, some of which have also developed fresh-water forms in Europe and North America as well as in South America. The fresh-water forms of South America and Africa are local adaptations of marine families that require no change in the present condition to account for their origin.

The second group comprises the Lepidosirenidæ, Osteoglossidæ, Siluridæ, Characinidæ, Pœciliidæ and Cichlidæ. Of these the Lepidosirenidæ are relicts of a former widely distributed group, and it requires no land connection to satisfactorily account for their presence in Africa and South America. The Pœciliidæ live indifferently in marine, brackish water or fresh water. They reach their maximum development in the fresh waters of Mexico and Central America. The marine species are found along the shores, not at sea, and there is, therefore, at present, no known means of getting them from the American to the African shore. Nevertheless, *Fundulus* is found on both sides of the Atlantic, and there must have been an intermigration much more recent than the youngest possible land connection between Africa and South America, or else there has been a very long persistence of this type. A land connection, while not absolutely required for this family, would be very convenient.

The Siluridæ are in part marine. All of the South American forms of Siluridæ can be derived from the marine Tachisurinæ, and the same is probably true of the American members of the family. Furthermore, the catfishes are found in North America, Europe and Asia and have been recorded in North America from the Tertiary. A land connection between Africa and South America is, therefore, not absolutely required to account for their presence in both continents, though, as in the case of the Pœciliidæ, such a connection would be very convenient.

The Cichlidæ and Characinidæ are abundant in tropical America and in Africa, a few species of Cichlidæ being also found in India. There is no known means by which these two forms could have crossed the existing gap between Africa and South America. There has been no exchange of species in recent times, for there is no species or genus common to the two continents. The South American and African elements of these two families must have been derived from some intermediate land mass or must have gone from one continent to the other over a land bridge. That this connection, whatever it was, must have been obliterated before the tertiary, is evidenced by the facts that the tertiary deposits of Taubaté and Parana show existing genera and that there are many South American types, as the Gymnotidæ, Electrophoridæ, Bunocephalidæ, Loricariidæ, Argiidæ, Pygidiidæ, Callichthyidæ, Hypophthalmidæ and others not found in Africa that have all



arisen in South America from the Characinidæ and Siluridæ since the separation of the two continents.

Similarly, other families found in Africa and not in South America have either arisen in Africa since that time or have immigrated from the east.

A land connection, whether a land bridge, intermediate continent or land wave, between the two continents is imperative. This land connection must have existed before the origin of existing genera and before many of the existing families.

12 MEMBERS OF THE GYMNOTIDÆ. *a*, *Sternarchorhynchus curvirostris* (Boulenger); *b*, *Steatogenys elegans* (Steindachner). *c*, *Sternarchus brasiliensis* (Reinhardt); *d*, *Eigenmannia virescens* (Valenciennes) *e*, *Giton fasciatus* (Pallas); *f*, *Rhamphichthys marmoratus* (Castelnau).

B. *Conclusions and Bird's-eye View of the Problems.*

America, south of the Tropic of Cancer, contains four (or five) distinct faunas. These faunas are the Transition, the Mexican, the South American and the Patagonian.

The northernmost, or Transition fauna, is characterized largely by instrusive elements from both the north and the south. It is found on the Atlantic slope from the tropic to the Isthmus of Tehuantepec and on the Pacific slope of this Isthmus.

The Mexican fauna is unique, and occupies a narrow strip inclu-

13. *Cichlasoma bimaculatum* L.

14. *Crenicichla saxatilis* L. TWO MEMBERS OF THE CICHLIDÆ, of which there are about 150 known species between the borders of the United States and Patagonia.

ding the valley of the City of Mexico and the Lerma basin draining to the west, and the Rio San Juan, a tributary of the Panuco, draining to the east. While containing intrusive elements from the north, it contains none from the south, and its fauna is so distinct from either that there is slight hesitation in considering it as equivalent to the American, South American and Patagonian faunas.

The third, the South American fauna, is sharply divisible into the Brazilian and Andean. The Brazilian occupies the rivers from Southern Mexico to Buenos Aires and from Para to Callao, exclusive of the high Andes. This fauna is the richest in species in the world. From this region about ten per cent. of all the known fishes have been recorded. The Andean, from 3,000 to 5,000 feet and over above sea-level, while possessing some forms in common with the Brazilian, is quite distinct. The species inhabiting this region would cause surprise if found at Manaos; those of the Pacific slope would not.

The Patagonian fauna is among the poorest in the world. It occupies the Rio Negro basin, and everything lying south of it and a line joining it with Valparaiso. Its fauna has been considered in detail.

For convenience these faunal areas may be enumerated as the following 'regions' of unequal value. (1) Transition. (2) Mexican. (3) Brazilian. (4) Andean. (5) Patagonian. I am not sure but that the Titicacan basin constitutes a 'region' distinct from the Andean north of Titicaca.

The origin and distribution of the fresh-water fishes of tropical South America have come about as follows: In the earliest tertiary tropical America consisted of two land areas, Archiguiana and Archamazona, separated by the lower valley of the Amazon, which was still submerged. There was a land mass, Helenis, between Africa and South America, possibly in contact with Guiana in South America and some point in tropical Africa.[1]

This land mass was inhabited, among other things, by Lepidosirenidæ, Pœciliidæ, Characinidæ, Cichlidæ and Siluridæ. This land-mass sank beneath the surface of the ocean, forcing the fauna in two directions, towards Africa and towards South America, exterminating all types not moved to the east or the west. From these two rudiments have developed the present diverse faunas of Africa and South America, each reinforced by intrusives from the ocean and neighboring land areas and by autochthonous development within its own border. The one fauna can not be said to have been derived directly from the other.

The connection between Africa and South America existed before the origin of present genera and even before the origin of some of the present subfamilies and families, some time before the earlier tertiary. There has never been any exchange between Africa and South America since that time.[2] There must have been an intimate connection between these two continents, for there is no evidence such as identical species or genera on the two coasts to indicate an occasional or accidental exchange of types across the Atlantic since the formation of existing genera, therefore such an interchange across the ocean probably never took place. The east Brazilian land mass south of the Amazon (Archamazona) must have become stocked from the western end of Helenis, or Archiguiana, very early, for it contains many genera peculiar to the region, indicating a long separation, and tertiary fresh-water deposits in this area contain existing genera of fresh-water fishes.

When, later, the Cordilleras arose out of the ocean at a distance from Archiguiana and Archamazona too great to be traversed by colonists from them, their developing streams and arms of the sea, connected with brackish, and, later, fresh-water lakes, all became populated with marine types. In the north where they later came into competition with immigrants from Archiguiana most of them were exterminated with the continued elevation of the land. On the south, which was not, or not so easily, reached by immigrants, *Orestias, Gastropterus* and *Protistius* remain in the high Cordilleras of southern Peru as relicts of these marine species. Later, as the distance between the

[1] This paragraph is an outline of part of von Ihering's Archiplata-Archhelenis theory.

[2] There has been a remarkable parallelism in the evolution of genera of cichlids, characins and catfishes on the two continents that I hope to take up in another place.

Cordilleras and Archiguiana was reduced, these mountain streams, especially those of Ecuador and Colombia, became populated by stragglers or accidental visitors from the land areas to the east. These in their turn, with the elevation of the Andes, became modified and gave rise to the genera now peculiar to both slopes of the high Andes, *Pygidium, Eremophilus, Chætostomus, Arges, Cyclopium, Astroblepus,* etc.

With the further elevation of the Cordilleras into a continuous barrier and the formation of the Orinoco, Amazon and La Plata valleys through elevation and the débris brought from the land masses and the development of the enormous fresh-water system occupying these valleys, this system, particularly the Amazon, became progressively colonized from the older land areas and became the center of unparalleled adaptive radiation and a new center for distribution which it has remained to the present time. The comparatively few types inhabiting the old eastern land masses found themselves in possession of a continent and diverged in every conceivable direction. I have hinted at this divergence in a recent article (*Biol. Bull.,* VIII., pp. 59–66). It will be considered in detail in a forthcoming monograph of the characins[3] of America.

From the Amazon species moved in all directions till they met barriers of one sort or another. The Pacific slope fauna is derived to a very large extent from this later divergent migration over the Isthmus of Panama and through the valley of the Atrato, between the western and coast Cordilleras of Colombia.[4] Others possibly crossed over the

[3] The characins are a family of fresh-water fishes that, in America, range from the border of the United States to some distance south of Buenos Aires. They form about one third of the entire South American fresh-water fauna, and have diverged in adaptation to diverse food, diverse habitat and diverse enemies to fill nearly every niche open to fishes. The ends of the three lines of adaptation to different food give us mud-eating forms, with long intestinal tract and no teeth; flesh-eaters with shear-like teeth, that make bathing dangerous to life and that cut their way out of nets; and conical-toothed forms, with sharp, needle-like teeth and comparatively huge fangs. Greater diversity could scarcely be imagined, and one is lead to suspect that some of the forms are over-adapted. In their divergence in form they have reached almost every conceivable shape. . . .

Diverging among themselves as has been noted above, they have approached, or paralleled many members of the diverse families of North American fresh-water fishes. Our shads and fresh-water herrings have their counterparts in *Elopomorphus, Potamorhina* and *Psectrogaster;* our salmon are paralleled by *Salminis* and *Catabasis;* our minnows are paralleled by *Tetragonopterus* and its relatives. It will take but a slight flight of the imagination to detect the striking similarity of some of the Hydrocyninæ to our gar pikes; our mullets are duplicated by *Prochilodus;* our top-minnows are mimicked by *Nannostomus,* and even our festive darters are duplicated by a member of this most remarkable family, *Characidium fasciatum.*

[4] See SCIENCE, N. S., XXII., pp. 18–20.

Andes east of Guayaquil before the Andes reached their present height. The Pacific slope fauna is less different from the Amazon fauna than that of the coastwise streams of Minas, if the number of peculiar genera is used as a measure of difference. The origin of the fauna of the plateau of Mexico is a separate subject.

The points of strategic importance for ichthyic chorology in South America are, therefore: (*a*) western Colombia and Panama; (*b*) Guayaquil to the Amazon, across the Andes; (*c*) the tableland of Guiana, Archiguiana; (*d*) the Rio San Francisco, with the Ria Parahyba and the headwaters of the Tieté and Rio Grande, in Archamazona; and (*e*) the area between the Rio Negro and the La Plata. It is these regions which will yield the richest scientific harvest to any museum undertaking South American exploration.

FACTS ABOUT NOSTRUMS

BY HORATIO C. WOOD, JR., M.D.
UNIVERSITY OF PENNSYLVANIA

THE quantity of secret and semi-secret drug mixtures consumed by the American people is enormous. While it is impossible to determine accurately the extent of the custom of self-medication a recent writer has estimated that over $100,000,000 is expended annually for so-called 'patent medicines.' The investigation of the causes which have led to the growth of this business affords an interesting study of human nature and also throws a light upon the subject of the effect on the health of the community. Since time was mankind has desired when sick the advice of some one who has devoted especial attention to the subject of relieving human suffering, and while here and there are scattered over the land adherents to various faddists, who, on account of religious beliefs or credence in some peculiar theory of health, have ceased to consult doctors, yet the overwhelming majority of the people still believe in the usefulness of the medical profession as well as of drugs.

The two motives which most commonly lead to experimentation with advertised nostrums are the desire to avoid calling in a physician and to save thereby the doctor's fee, and the hope that better results may be achieved than are offered by the regular medical profession. Occasionally, as in unsettled districts, the impossibility of obtaining medical advice forces 'home treatment,' but this condition is so infrequent that it may be practically disregarded.

In the majority of instances it is the indisposition to send for the doctor which explains the self-dosing, not always from the desire to save money, but at times from a sense of shame in annoying a busy man with some trivial complaint which the patient believes he can treat himself with equal benefit. This feeling covers the use of a large number of the less objectionable proprietary remedies such as the laxatives, but is also the predominant factor in the employment of the most diabolical of them all, the 'soothing syrups,' with which hundreds of non-thinking mothers are poisoning their children. One of the dangers, which attend all self-medication but apply with especial force to the habit of relieving seemingly trivial complaints, is that some serious trouble, still in its formative stage when proper treatment is most efficacious, is neglected until the damage wrought becomes irreparable. For example, a man is taken with what he believes to be an

ordinary 'stomach-ache,' due to indigestion, and buys some 'pain-killer' or 'dyspepsia tablet' with which he experiments on himself for two or three days; the physician called too late finds appendicitis gone on to a stage perhaps where a fatal issue is unavoidable. Again, in the spring of the year a feeling of languor is diagnosed by the doctor-patient as 'spring fever,' for which he doses himself religiously with some stimulating 'blood purifier,' while the real nature of the case may be a beginning typhoid fever. The list of such conditions which may and do occur might be drawn out *ad infinitum,* but enough has been said to show the great fundamental objection to all nostrums.

This danger, it must be confessed, however, is after all a comparatively remote one. The great imminent peril which threatens the life and health of the nation lies in the fact that a large number of these remedies contain poisonous and habit-forming ingredients. The most horrible instance of this is the 'soothing syrups.' These are universally loaded down with morphine. The immediate deaths which have followed an overdose of some opium-containing 'soothing syrup' are numerous enough, but the thought of the hundreds of children condemned from the cradle to a life of invalidism, to which the grave is preferable, by the formation of a morphine habit from which the delicate nervous system is never able to recuperate, is horrible. The poor ignorant mother is usually not to blame, but the devilishness of the nostrum vender who deliberately sets out to poison helpless infants puts him below the murderer in criminal immorality, and the supineness of a government which permits such crime to go unpunished must bring a blush of shame to the face of every thinking citizen.

Another frequent offender of this class is the 'cough syrup' or 'pectoral.' These nearly all contain either opium or some closely allied drug. Those of the headache powders and other remedies for the relief of pain which do not contain opium almost without exception are preparations of acetanilid, a substance derived from coal tar, which, although perhaps not so dangerous as morphine, produces an insidious weakening of the heart when used repeatedly, and whose victims number into the thousands.

Those who employ patent medicines from the second motive mentioned, that is, with the hope of obtaining better results than are promised by the regular medical profession, are naturally found chiefly among the less educated classes of society. To an intelligent mind it is evidently improbable that an untrained observer whose interests are purely commercial should know of some remedy of great value which generations of devoted physicians and scientists had failed to discover. The claims made by this group of nostrum mongers are so palpably impossible as to be ridiculous to all thinking men. Yet it is surprising to find how many persons of presumable intelligence, driven by the des-

peration of an incurable disease grasp at this frail straw in the hope of being rescued from untimely death. Such are found especially among cases of consumption, cancer, spinal disease or other similar chronic complaints whose outlook is unfavorable. Many of the nostrums belonging to this class are quite inert, while others contain opiates or stimulants which give temporary relief from symptoms but only hasten the end.

The question must present itself most forcibly, if the statements outlined above are true, how does it come that such a large body of the people continue to use these irrational remedies? This question is usually answered by attributing the results to 'shrewd advertising.' If shrewdness is synonymous with falsehood and blackmail the answer is correct. While it is true that an enormous amount of money is spent in advertising, yet back of all these advertisements is a mass of deceit which in any other business would prove ruinous.

It is necessary to digress for a moment to obtain a comprehension of the factors which have made successful commercial methods which under ordinary circumstances would mean certain failure. All patent medicines, with a few exceptions, as the laxatives, may be divided into two classes, the inert and the dangerous. The harmful remedies which are employed are usually either opium, cocaine, alcohol or acetanilid. All of these are drugs whose use is liable to lead to a craving for more. It is evident that if Peruna once starts an alcohol habit, or if Bull's 'Cough syrup' makes an opium fiend, or Birney's 'Catarrh Cure,' a cocaine habitué, the future sale of that remedy is assured. After once being persuaded to consume the first bottle of the deadly nostrum the financial and moral wreck of the victim is an easy matter. It is asserted that so widespread has become the use of some of these remedies that cures are now being advertised for the relief of the Peruna habit. With the inert nostrum the conditions are somewhat different. These depend for their prosperity upon the large number of credulous persons from among whom new customers may be obtained when some old customer awakes to the fact that, in the language of the college youth, 'he has been stung.'

It is clear that the task of the purveyors of inert frauds is a more difficult one than that of the vender of habit-forming poisons. But the methods of procuring new customers is essentially the same in each instance. To obtain fresh victims there is no depth of immorality to which the manufacturer of the nostrum will not stoop. The lies are of manifold variety, but of a few classic types.

The first of these, which may be denominated as the lie simple, is the extravagant claim to cure all sorts of conditions, based simply on the statement of the owner of the drug. Sometimes these are fortified by offer of 'money back if not satisfied' or one hundred dollars, or a

thousand, or a million—it makes no difference, since it is never paid—'for a case which can not be cured,' etc. As an example of the sincerity of these offers an illuminating correspondence is quoted from the *Journal of the American Medical Association,* as follows:

April 21st, 1906.

Drs. Brown and Lenox, Rogers, Ark., send us an account of a case of catarrh which was not cured by Hall's Catarrh Cure. The patient, Mr. Robert Parks, consulted these physicians for catarrh and stated that he had just finished his twenty-sixth bottle of Hall's Catarrh Cure, but that instead of being benefited he was worse. Mr. Parks wrote to the Cheney Medicine Company, the maker of Hall's Catarrh Cure, giving his experience, and asking the firm to pay $100.00 in accordance with the advertisements: "$100.00 for any case of catarrh which it will not cure" or to refund the money he had paid.

The following is a copy of a letter which he received in reply:

TOLEDO, OHIO, March 30th, 1906.

ROBERT PARK, ROGERS, ARK.

Dear Sir: Yours of recent date received and in reply will say, as we have already said, that many cases require much more than you have taken for a cure, and as this is the case and Hall's Catarrh Cure is not placed on the market on the 'No cure, no pay' plan, we would not feel at all justified in refunding the money paid for this trial of the medicine. Will further say that you have failed to state much regarding your disease, symptoms of same, of how long standing, symptoms of the action of the medicine, etc. Had we more information concerning your case, we might have been able to make some helpful suggestions regarding the treatment."

Yours very truly,

F. J. CHENEY & Co.

A. G. A.

The second type of falsehood which is used by these manufacturers is the testimonial lie. Some obscure citizen who has been rescued from some imaginary complaint spills his gratitude to the nostrum manufacturer in a lurid if ungrammatical epistle. Sometimes, however, it is not an obscure citizen, but a prominent one, a senator, or an admiral of the United States Navy or some one equally before the public eye. Some of these testimonials are absolute fabrications. The boldness with which nostrum venders manufacture evidence is astonishing, and only comprehensible in view of the fact that there is usually no legal punishment. Some years ago, Duffy's Malt Whiskey Company stated in their advertisements that it was recommended in consumption by Dr. ———, one of the most prominent physicians of Philadelphia, when as a matter of fact he had never tasted it nor prescribed it; but the courts offered no redress and the only means of cleansing his reputation was an advertisement in the daily papers. Some of the testimonials are bought. (There is a firm in this country which is engaged in the sale of testimonials to nostrum manufacturers.) The following circular speaks for itself.

As you are aware, we have your testimonial to our remedy. It has been some time since we have heard from you, and so we thought best to make

inquiry as to your present state of health, and whether you still occasionally make use of Peruna. We also want to make quite sure that we have your present street address correctly, and that you are making favorable answers to such letters of inquiry which your testimonial may occasion. Remember that we allow twenty-five cents for each letter of inquiry. You have only to send the letter you receive, together with a copy of your reply to same, and we will forward you twenty-five cents for each pair of letters. We hope you are still a friend of Peruna, and that our continued use of your testimonial will be agreeable to you. We are inclosing stamped envelope for reply.

Very sincerely yours,

THE PERUNA DRUG MANUFACTURING CO.,

PER CARR.

It would seem time for the law to intervene to stop this noxious traffic. Owing to recent agitation in certain magazines some effort has been made to restrict it, but it has met with vigorous opposition from a venal lobby. Those interested in the business argue that this is a free country and that each one must be allowed to use his own judgment as to what is harmful or beneficial. Such sophistry would be laughable if it were not used with such deplorable results. In almost every state of the union the practise of medicine is rigidly controlled. The applicant must show not only proof of medical education, but must pass an examination given by the state, before he is licensed to practise. As sensible an argument would it be to say that every one has a right to practise medicine and that each one must use his common sense in choosing a doctor who is educated. In many states of the union there are laws regulating the adulteration of foods. In but one or two states are there laws preventing the sale of deadly poisons in the form of patent medicines.

Government is for the purpose of protecting society from the depredation of persons whose moral intuitions are below the average of the people in general. We hang murderers in order that they may find no further victims; we lock up thieves that our property may remain safe; we allow patent-medicine monsters to murder and to steal without restraint. The proprietors of these nostrums are to be classed as moral perverts, for while they may deceive the public with various statements concerning the value of their remedies, they themselves are in no wise deceived. Being so, it becomes the duty of our legislative bodies to protect the community. The general public does not and can not be expected to separate the truth from the falsehood about the value of unknown drugs. When the poor, uneducated, epileptic whose mind has been enfeebled by disease, reads in a respectable paper an advertisement backed with some testimonial, he can not know that the testimonial is false and that the claims are absolutely impossible, but readily becomes the dupe of the charlatan, throwing away both money and life in search of the 'Will-o'-the-wisp.'

There is now pending before the United States legislature a bill which the nostrum dealers cry out is a terrible crime against personal liberty and a ruination of a great business. And what is the terrible proviso which so frightens those engaged in patent medicine business? Simply that all proprietary remedies containing opium, cocaine or other poisonous ingredient shall state upon the label the exact amount of the poisonous ingredient present; as feeble and conservative a measure for this great evil as one could well imagine.

With any other measure of similar importance before congress the newspapers, which are the great voice of the people, would cry in such a tremendous chorus for relief that no legislator would dare to hesitate to pass the bill. But the silence of the newspapers and magazines, with a few notable exceptions, has been bought through the advertising columns. In this morning's paper I find an advertisement for Hood's Sarsaparilla which occupies space value, according to the published rates of the paper, of seventy-five dollars; Doctor Pierce occupies sixty-five dollars' worth; Cuticura is satisfied with thirty dollars' worth, and other advertisements in similar quantities bring up the day's total to $240. This does not include the smaller notices of drugs among the personal columns and small classifications. In the evening paper Duffy's Malt Whiskey has a prominent place with the picture of a 'grand old patriarch' who was enabled to reach the age of one hundred and four years through the constant use of this liquor, while one tenth of the entire issue is advertisements of secret remedies. Receiving as they do $900,000 a year apiece from this business, is it any wonder that the newspapers are disposed to keep silent concerning the evil of it? The mouthpiece of the nation is stopped with gold; let the people, therefore, speak directly and bid their legislators save the ignorant and the innocent from the voracity of the conscienceless degenerates who are robbing them of health and money at the same time.

THE TIMES AND PLACES OF EARTHQUAKES[1]

By Professor H. H. TURNER, F.R.S.,
OXFORD UNIVERSITY

THE occurrence of several disastrous earthquakes and eruptions during the last few months inevitably suggests the question whether all these events may not have a common and determinable origin. To avert any of these disasters, even to modify them in the slightest degree, may be entirely hopeless; but the vaguest foreknowledge of their probable occurrence might be of untold value in saving life and property. Has modern research obtained any clues which enable predictions to be made, or promise that prediction may be possible in the near future? It must be frankly admitted that as yet our knowledge is so slight as to have no commercial value; but still, there are one or two clues in the hands of those working at the subject which may ultimately lead them to more directly useful knowledge. We have learnt something of the regions where earthquakes occur, and something of the times when we may specially expect them; and, though the something is in each case a very little, the magnitude of the issues involved lends it interest.

Systematic observation of earthquakes is only about a quarter of a century old, and for fairly complete records of all the shocks occurring in different parts of the globe we can date only from 1892. Before that date information could only be collected on the spot, and was thus frequently lost; but it was realized about 1890 that a series of earthquake observatories, with delicate instruments, could obtain records of shocks in any quarter of the globe, and identify the spot with certainty, even if there were no witnesses of the actual occurrence. From the records of these observatories it appears that there are every year some 30,000 minor shocks of earthquake in different localities, but of these only 60 are 'world-shaking' and observable from a great distance. Such numbers indicate immediately that, from one point of view, the San Francisco earthquake can not be regarded as exceptional; it was only one event out of 60 per annum. What rendered it disastrous was the existence of a great town in the shaken locality. But was the neighborhood known to be a dangerous one? Was it at any rate, suspected, so that the building of a great city there was an error of judgment? and is it advisable to rebuild the city in the same place? These are

[1] From the London *Times*.

questions of the gravest importance; and it is well worth while to review the little knowledge already accumulated with the utmost care to see whether it will give us even provisional answers to them.

Professor Milne, in the tenth report of the British Association committee, refers the 'world-shaking' earthquakes observed in the six years 1899–1905 to thirteen great earthquake regions, designated by the first thirteen letters of the alphabet. Three of these, I, J and L, are responsible for only five, three and two shocks respectively, and are thus of small importance compared with the others, which average about forty shocks each. Excluding them for the present, the remaining ten regions lie approximately in two rings on the earth's surface, a configuration which is most strikingly apparent when the regions are marked on a globe. The more important ring includes the following seven regions: A (Alaskan coast), B (Californian coast), C (West Indies), D (Chilian coast), M (South of New Zealand), F (Krakatoa region), E (Japan). Its center is among the conspicuous group of islands which includes Tahiti, and the radius of the ring is about 65 degrees. The other ring has its center at the opposite point of the earth, which is in the Sahara desert; and at a radius of 50 degrees from this center lie regions G (between India and Madagascar), H (the Azores) and K (Tashkend). Now, this is not merely a convenient geographical summary, but a physical fact of vital importance, according to recent researches by Professor Jeans. In a remarkable paper read before the Royal Society in 1903 he gave reasons for believing that the earth is by no means a sphere or a spheroid, as we have been accustomed to think, but is of a pear-shape. Under gravitational stress it is continually approaching the spheroidal form—the pear is being crushed into a sphere by its own attraction; and the result is a series of earthquakes. These naturally occur in the weakest places, and if any one will experiment in crushing a pear towards a spherical shape, or even draw a diagram and consider where the weakest points would be, the reasons for the existence of two rings of greatest weakness will readily suggest themselves. The ends of the pear are the centers of these rings, one in Africa, one in the Pacific; and when once this is pointed out, the pear-shape of the earth is, according to Professor Sollas, 'obvious to mere inspection; it is a geographical fact and not a speculation.' Professor Sollas is indeed responsible for the particular suggestion above sketched; for Professor Jeans had originally proposed a different axis, which he withdrew in favor of the obvious improvement. The confirmation of Professor Sollas's view from the distribution of earthquake centers is remarkable. It does not seem, however, quite certain which is the blunt end of the pear; it has been hitherto placed in Africa, but there seem to be several reasons for regarding

Africa as the stalk end. This point can not, however, be dealt with here. The important thing is that there seems to be a real reason for the occurrence of earthquakes in these particular regions, and that they will probably continue to occur there. Professor Jeans's conclusions have recently been examined by Lord Rayleigh, who announced at the Royal Society only a few weeks ago that he found them generally confirmed, and that we must regard our earth as at present in a state far from stable.

The lessons to be learnt from the distribution of earthquakes in space are accordingly tolerably plain in theory, though in practise we may not be able to take advantage of them. If we would be particularly safe from earthquakes, we must take up our abode near one of the ends of the pear—either in Africa or in the Pacific. There is also a region of safety between the two dangerous rings—in America generally, for instance, excluding the west, or in Siberia. But the dangerous regions include so vast and so valuable a part of the earth's surface that it is impracticable to leave them unoccupied. Moreover, our knowledge is as yet not specific enough. In the dangerous regions themselves, some parts are much more dangerous than others; for instance, Japan, which is reckoned above as a single region, can be divided into at least fifteen distinct seismic districts. As observations are accumulated we may be able to make similar partitions of the other regions. For the present the general attitude towards earthquakes will probably be similar to that towards other dangers, such as those of travels and voyages for instance; the risks must be incurred. We know that there are at times fatal tornadoes; but other interests are at stake, and we put to sea in the hope that none will occur during our voyage.

We come to the second point, the distribution of earthquakes in time. Are there seasons of special activity such as the recent occurrence of several disasters seems to suggest? Here our knowledge is slighter still, and the observed facts have not yet been coordinated by a mathematical investigation. Still there seems to be some evidence in support of the view that exceptional irregularities in the rotation of our earth may be responsible for an increased number of earthquakes at particular times. That the evidence is slight must be attributed to the shortness of the time during which it has been possible to obtain it, and not necessarily to inherent weakness in the evidence itself. The brevity of the earthquake record has been mentioned above; that of irregularities in the earth's rotation is longer; but the discovery that such irregularities existed was made only twenty years ago, though the phenomenon was then traced back through the old observations. The irregularities are systematic in character, and the law governing

them is approximately known already; so that, if the presumed connection between them and earthquakes is confirmed, we may be able to predict periods of great earthquake frequency. Such periods would be in some respects analogous to the times of spring-tides. It is a familiar fact that at new and full moon the tides are much greater than when the moon is at the quarters. The reason is that we have two tide-raising bodies, the moon and the sun, which sometimes act in concert, and then we get large tides; sometimes in opposition, and then we get small tides. If the influence of these two bodies were more nearly equal, instead of the moon being so predominant a partner, we can imagine times when the tides would be barely perceptible. Similarly there are apparently two contributors to the variation in our earth's rotation, which sometimes act in unison and sometimes in opposition. They are more nearly equal in influence than are our moon and sun; and consequently there are times when these two contributors nearly balance one another and the axis of rotation remains almost steady. But in due time the contributors reinforce one another and the axis acquires a considerable 'wobble.' Each end of the axis then describes a curve composed of wide sweeps and sharp bends; and the evidence seems to be that at the sharp bends we are particularly liable to earthquakes. The exact statement of the case as given by Professor Milne in his Bakerian lecture, 'Recent Advances in Seismology,' delivered before the Royal Society, on March 22, last, is as follows:

> **In a period of nearly thirteen years (1892 to 1904) I find records for at least 750 world-shaking earthquakes, which may be referred to three periods continuous with each other, and each two-tenths of a year or 73 days' duration. The first period occurred when the pole movement followed an approximately straight line or curve of large radius, the second equal period when it was undergoing deflection or following a path of short radius, and the third when the movement was similar to that of the first period. The numbers of earthquakes in each of these periods taken in the order named were 211, 307 and 232 —that is to say, during the period when the change in direction of motion has been comparatively rapid the relief of seismic strain has not only been marked, but it has been localized along the junctions of land blocks and land plains where we should expect to find that the stress due to change in direction of motion was at a *maximum*. Until the magnitude of these induced stresses has been estimated it would be premature to assume that the frequency under consideration is directly due to change in direction of pole movement, it being quite as likely that both phenomena may result from a general cause.**

It is eminently to be desired that a mathematical investigation of the point should be undertaken; but the difficulties are very great, and as yet no one has had the time and courage to attack them. It will be seen, then, that the seismologist is as yet not able to give forecasts of any commercial value, though he is by no means without hope of doing so.

There are, however, some lessons of immediate practical importance which have been learnt by seismological study; we may again quote from Professor Milne's Bakerian lecture:

> At the Imperial University of Tokio a platform was constructed which by means of powerful machinery could be made to reproduce earthquake motion of varying intensity. On this table large models of masonry, wood, and metal designed to resist expected seismic accelerations were tested. This table has been to the builders in Japan what a testing tank in a dockyard has been to constructors of large vessels. The ultimate result of these and other investigations has been to modify and extend the rules and formulæ of ordinary construction, and now in Japan, as opportunity presents itself, new types of structure are springing up. These have withstood violent shakings which have materially damaged ordinary types in the neighborhood. While much has thus been done to reduce the loss of life and property, the Japanese government, stimulated by the results of this experience, has been encouraged to extend its support to seismological investigations in general.
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> In 1886 the chair of seismology was established at the Imperial University, and since 1892 there has been in existence a seismological investigation committee, which has already issued 70 quarto volumes. At the Central Meteorological Observatory in Tokio records are received from nearly 1,500 observing centers.

From these paragraphs it will be seen that there are questions which merit the close study of engineers and architects whose work lies in the dangerous regions, though but little attention has been paid to them except by that wonderful little people who have already taught us more than they learnt from us. It is some consolation, doubtless, to reflect that modern seismology owed its origin to Englishmen. It was the little community of Englishmen who were invited in 1880 to 'pitch their tents on the trembling soil of Japan,' in order to teach the Japanese something of western civilization, who began to study these earthquakes, and enlisted the sympathy of the Japanese government in the matter. The sequel in this case as in others suggests comparison, not perhaps between the disciple and his master, but between the treatments which they have received at the hands of the world in general and governments in particular. While seismological research has been stimulated and rewarded in Japan in the manner above indicated, Professor Milne's heroic exertions in England have met with very little recognition. Practically single-handed he has organized forty stations all over the world, where records are obtained, and has carried on the correspondence and clerical work necessary to keep them in communication and coordinate the records. Until recently the only assistance accorded him of any kind was a small grant of about £20 a year made by the British Association—all they could afford in view of the numerous claims on their small funds—which barely sufficed to buy the paper and chemicals for his own recording station at Shide.

Appeals for government aid have so far been fruitless; though recently one or two welcome private donations have been forthcoming.

It will, no doubt, be objected to this comparison that an important consideration has been omitted. Seismological questions are of urgent practical importance in Japan, but not in England. That is true, and we all hope that it may remain true; but our guarantee is not absolute. Whether the regions of danger are permanent or shifting is just one of the questions which the whole world is interested in answering, and which can be answered only by patient and laborious research. The British Isles are far from being in a specially safe region; in fact, they lie almost exactly on the smaller dangerous circle above-mentioned, through Tashkend, the Azores and the Indian region; and though earthquake activity seems to be at present limited to these three regions, and so far as it strays in our direction seems to find an outlet rather beyond us (in the region labeled J by Professor Milne, between Iceland and the North Cape, where three earthquakes were recorded in six years), we have no right to assume that this state of things is more than temporary.

During the last year or two, however, more has been done in Europe generally to follow the lead of Japan; international cooperation in seismological work has been organized in Germany; and though the adhesion of some important countries is not yet certain, owing to various difficulties which need not be noticed here, it is hoped that these may be smoothed away in time. If so we may look forward to a welcome strengthening of the corps of workers in seismology, though there is still more than enough work for them all to do.

VOLCANOS AND RADIOACTIVITY

By Major C. E. DUTTON, U. S. A.

ONE of the commonest and perhaps the most impressive of natural phenomena, the volcano, has hitherto been without any explanation of its cause, though it has been before the world a subject of theory for many centuries. The reason for this is quite apparent. We perceive the action of the volcano upon the surface and we know what it does. But the theater of its origin and the development of its energy are far below the surface of the ground, out of reach of inspection or direct observation. Human ingenuity has been baffled in its efforts to explain the phenomenon because of the want of observed facts and the impossibility of obtaining them. But while we are, and probably always shall be, unable to directly inspect the seat of origin of the volcano, there are certain inferences in connection with them which have attained a degree of probability which entitles us to use them as facts which may limit speculation and confine it within very narrow boundaries. I purpose to mention these inferences in order to see the general nature of the solution to which they point; for unless I am greatly mistaken, they will show us that we are close upon the verge of a solution.

1. The first fact to be mentioned is the solidity of the earth. It is so well known that I shall not dwell upon it and merely mention it in order to bring it, together with other facts, into the same series or group.

2. The second fact is the comparative smallness of the extravasated masses in any single volcanic eruption. In order to obtain an idea of the relative magnitude of an erupted mass, let us draw upon a true scale a segment of one degree of the earth's surface, of an arbitrary thickness—say thirty miles. Upon this segment draw the profile of Vesuvius. About a mile below the surface, beneath the volcano, draw the reservoir of lava, having the same mass as the volcano itself. It may have any thickness and any form, and is subject only to the condition that the capacity of it is the same as the mass of the erupted material. Now Vesuvius is built of I know not how many individual eruptions, but let us say one hundred, though I presume that there were, in reality, very many more. A single average eruption would be the hundredth part of the volume of this reservoir. But there are eruptions known which are many times greater than the average of those of Vesuvius. The largest known in the United States are in

the Snake River Valley, and while we are not in a position to compute with accuracy their dimensions, we can say with confidence that the volume of the largest of them does not exceed two cubic miles. The great eruption of the Skaptar Jokul, in Iceland, in the year 1783, was estimated by Dr. Thoroddson to have outpoured twelve or thirteen cubic kilometers, or three cubic miles of lava. The greatest eruption of which we have any estimate, and that is a very crude one, was at Tomboro, on the island of Sumbawa, which was estimated to have discharged about six cubic miles of lava. This estimate is regarded as very excessive.

On the same scale as before, these two eruptions are represented, and you perceive how insignificant they are in mass in comparison with the whole of the surrounding earth.

3. The third general fact is the repetitive nature of volcanic eruptions. A single outbreak with none following is an exceedingly rare phenomenon. Many eruptions, going often into the thousands, occur before the climax is reached and the decline of activity follows. The reason why a volcano, when its vent is once open, does not discharge all the material in its reservoir in one stupendous belch and then close up forever will be shortly brought up.

4. The next general fact, which we can not claim to be proven, but for which there is a growing mass of strong and highly concordant evidence, is that the seat of the reservoir is very shallow and never more than three miles deep. Very rarely is there any indication of its being more than two and one half miles deep, and it is certain that in many cases the depth is less than one mile. The indications are that most of the volcanic eruptions originate at depths between one mile and two and one half miles. The evidence of this is furnished by the earthquakes which almost always accompany them and which are associated with them in such a way as to leave no doubt or question that they are produced by the volcanic action. The radiation of the tremors of an earthquake from their source in the earth is governed by substantially the same law as sound. The intensity of these tremors where they reach the earth's surface varies in a manner which is dependent upon their depth of origin. In the discussion of the Charleston earthquake, I pointed out one method by which that depth can be approximately computed from the distribution of critical points of the surface intensity. The method has been sharply criticized by able seismologists as being liable to error through refraction of the rays of propagation through rocks and media of variable density. But I observe that all of them use that method with surprising consistency and satisfactory results.

The efficiency of this method depends mainly upon the accuracy with which the intensity can be estimated along a line radiating from

the epicentrum. It often happens that the intensity is so much affected by the local nature of the soil and rocks that all estimates become so uncertain as to be very misleading, and all attempts to draw conclusions from them must be affected by large errors or may fail entirely. On the other hand, in many cases the results are safer and surer than would be supposed, and we are able to give a graphic representation of the curve of intensity which must be very near the truth. In general, when an earthquake is very strong at the epicenter and quickly fades out away from it, we can say with confidence that its centrum is very shallow. If the intensity fades out slowly and the quake is felt at great distances, we can rely upon its centrum being very deep. When, therefore, we have not the means of estimating the intensity at the critical points, if we have the means of estimating the maximum intensity of the quake and of knowing how far it is felt, we can still form, not, indeed, a precise or accurate estimate of its depth, but a roughly approximate one.

A qualification of the foregoing may be introduced here. The earthquake is no doubt the fracturing or sudden yielding of the rock masses immediately above the lava reservoir. We can only vaguely conjecture the distance which separates the zone of fracture from the zone of melting. But in no case could it be so great as a mile without making itself sensible in the greater depth of the quake. We must, however, increase slightly our estimate of the depth of the lava beyond the estimated depth of the quake.

We may now proceed to state the probable cause of volcanic eruptions. They are caused, I conceive, by a development of heat resulting from radioactivity in limited tracts at a depth of one to three—at the very utmost not over four—miles from the surface, which is sometimes sufficient to melt the rocks affected by it. The melting is gradual, and when a sufficient quantity is melted, the water which it contains becomes explosive and usually suffices to break through the covering, constituting an eruption. When all the lava is erupted, and the reservoir is exhausted, it closes up for a time. If the heat continues to be generated, more lava is melted, and in due time another eruption occurs. The process may be repeated again. It may be repeated hundreds or thousands of times. The volcanic action may continue in the same place for hundreds of thousands, or even millions, of years, or it may repeat itself only a few times, or may even occur only once. Indeed, it may fail altogether to erupt to the surface, and in many cases does fail. In other words, it goes through the entire process of preparing for an eruption and does not consummate it.

This view enables us to explain the repetitive character of volcanic eruptions, which is, perhaps, their most striking and characteristic feature. It is in strong contrast with the view long held that the lava

reservoirs are a part of the original constitution of the earth, and have lain in their present position through all the vast period of the earth's evolution, waiting for a convenient occasion to explode and pour forth their fiery contents. It regards the reservoirs as having no real existence as such, and as containing no liquid eruptible contents until some source of heat acts upon them and liquefies a portion of the strata, thus giving rise to the reservoir. When a sufficient quantity of the lava is melted to rupture its covering, the eruption follows. It continues until all the lava which exists for the time being in the reservoir is extravasated. And when all of its ammunition is expended, it must close its action until a fresh supply is provided.

By an increase of heat, we can readily understand the existence of the lava reservoirs in such anomalous positions near the surface of the earth. The horizon of melted lava, which has a temperature of about 1,000° or 1,200° C., if it depended wholly upon the secular cooling of the earth, would be more than thirty miles below the surface, or even forty miles below. We can not suppose that the cooling of the earth is so extremely unequal as to bring the isotherm of 1,000° C. at one place within two miles of the surface, and in another place, carry it thirty or forty miles below. It is equally difficult to imagine any subterranean disturbance or displacement which could mechanically thrust up near the surface a portion of the solid nucleus of the earth. Such a displacement is not warranted by the geological facts; for while volcanic eruptions occur frequently in localities where the strata are much displaced, they also occur where there has been no displacement of any moment since the Cambrian age.

A singular class of phenomena is found in the so-called mud volcanos which have always been a great puzzle, but which are easily explained by this cause. We find them in Central America and in Java, and the remarkable case of Bandai San, in Japan, is well remembered. These volcanos must have their origin at less depth than the lava eruptions. The temperature of erupted mud is not accurately known, but it can not be less than 400° or 500° F. The generation of heat half a mile below the surface would be a sufficient explanation of their origin and action.

Why should eruptions always emanate from shallow reservoirs and never from deeper ones? Or, according to the view here put forth, why are eruptive masses formed only at depths of two or three miles, and never at greater depths? I do not contend that no lava pools are formed at greater depths than three or four miles, but if they are formed, the lava is never erupted, and for the following reason. The pressure of the overlying rock at a depth of three miles is about 18,000 pounds to the square inch. At a depth of four miles it is about 25,000 pounds to the square inch. At such a pressure (25,000 pounds) it

would be impossible for water vapor to lift its covering and force a way to the surface unless it had a temperature greatly exceeding 1,200° C. It would have to be heated to a considerably higher temperature to do it. But with increasing temperature the heat is conducted away more and more rapidly until the loss of heat is equal to the quantity generated, and thereafter there is no increase of temperature. The generation of radioactive heat is a slow process, and the only method of its escape is by conduction away from the radioactive source. The rate of heat generation is constant and independent of the temperature, but the rate of loss increases rapidly with the temperature. Ultimately, as the temperature rises, a point would be reached at which the loss of heat becomes equal to the gain.

If an eruption from a deep source, say five or six miles, were to occur, we should expect that the temperature of the lava would be very high—probably a white heat—and that its mass would be very great. Its consequences might be disastrous beyond all precedent.

That volcanism is caused by the generation of heat near the surface was a belief which I expressed over twenty years ago in a chapter of the work on Hawaiian volcanos. Long study of the volcanic problem, in which every other theory failed and went to pieces under criticism, and this alone not only survived but grew more probable and in accordance with the facts, led me to the hazardous step of venturing to express it. At that time, no cause could be cited for the increase of heat, and the proposition met with no response, and no doubt justly. Geologists continued to look for the explanation of volcanos in the gradually waning remnants of the earth's internal heat. Within the last five or six years, however, physical science has made discoveries of a wonderful nature, which open a new field, indeed, a new world, in our views of the constitution of matter, and may throw a flood of light on the very subject of our inquiry.

The subject of radioactivity is so new and so surprising that it has had time only to establish a very few of the fundamental principles which lie at the basis of it. But so hotly is the matter pursued by many of the ablest specialists that each year shows a large increase in our knowledge. As this is familiar to all physicists, I shall allude here briefly only to such as are essential to our discussion. We have to regret that some of the most fundamental questions concerning radioactivity are as yet unsolved, though we can not expect that a new and far-reaching science should in six years have accomplished all of its immense possibilities.

A good many efforts have been made, by the use of the extremely sensitive quadrant electrometer, to ascertain by measurement the quantity of radioactive substances in the accessible portions of the earth. By taking samples of earth from varying depths and testing

them by the electrometer, widely variable quantitative results have been obtained, but in every instance the amount of radioactivity indicated much exceeds the amount required to compensate the loss of heat by the earth by conduction and radiation into space. For instance, Professors Elster and Geitel, of Berlin, who have made many discoveries and contributed many observations on radioactivity, placed 3,300 c.c. of garden soil within a closed vessel with an electroscope to determine the conductivity of the enclosed gas. Allowing it to stand for several days, the conductivity of the air became constant at three times the normal amount. This increase of conductivity, Professor Rutherford estimates, would be equivalent to that produced by the emanation from 7×10^{-10} grams of radium. If the density of the soil be taken as two, this corresponds to the emanation from 10^{-13} grams of radium per gram of clay. Now Professor Rutherford computes that the earth's loss of heat by conduction and radiation is equivalent to what would be supplied by 4.1×10^{-14} grams of radium per cubic centimeter of its mass. According, then, to the results obtained by Elster and Geitel, twice as much heat would be supplied by radioactivity as is lost by conduction and radiation into space.

This experiment with a small quantity of soil taken up in somebody's back yard will hardly be regarded as an accurate determination of such a quantity as the earth's supply of radioactive heat. But the question has been tested by many observers, whose results vary considerably, yet all are of the same order of magnitude. By sinking a pipe into the ground anywhere and sucking up a sample of the air from the soil, it is found to possess a much higher degree of radioactivity than the free air at the surface. It also has a marked degree of conductivity; and this conductivity falls to half of its initial value in a little less than four days, which is regarded as proving that it is due to radium emanation. The air of caves and cellars has been observed to have a marked degree of ionization, greatly exceeding the open atmosphere and the air in closed vessels. This is attributable only to the presence of radium emanation diffused from surrounding rocks or soils. Many common well-waters give satisfactory tests of the presence of radium emanation, which is soluble in water—more so than most gases.

The most pronounced occurrence of radium is in hot springs. Their waters always give evidence of its presence, and sometimes in quantities many times exceeding the air taken from the soil or cellars. Hon. R. J. Strutt, of Trinity College, has devoted much attention to the springs of Bath, and finds not only radium emanation in their waters, but actual radium in the deposits of the springs. The hot springs of Baden-Baden have been found to contain radium salts. M. Curie has tested a large number of the mineral springs of central and southern France and finds radium emanation in nearly all of them.

Mr. Boltwood, of New Haven, has devoted considerable attention to the study of radioactivity in mineral springs and finds that many of the waters of America contain radium emanation.

It does not appear that any extensive or systematic investigation of the emanations of active volcanos and volcanic gases has been hitherto made. The only one I can discover is the observation of Rausch von Trauenberg on the crater Vesuvius. The gases from that orifice produced marked ionization and a prompt discharge of the leaves of the electroscope. The subject, however, needs thorough investigation at many other volcanic vents.

The general result of the investigation, so far as it has gone, has been to make clear the fact that the amount of radioactivity in the earth much exceeds the amount which is necessary, so far as the heat generated by it is concerned, to compensate the loss of heat by conduction and radiation. In fact, it appears that the thermal condition at present is one of continual increase of internal temperature of a large portion of the earth, or is so in part; or else, is one of equilibrium between loss and gain. Undoubtedly the amount of radioaction varies somewhat widely in different portions of the earth's interior, in some portions permitting a loss of heat, in others permitting a gain. And when there is a gain, it may proceed in the portions near the surface so far as to liquefy the rocks, and thus furnish all the conditions necessary to volcanic eruptions.

One of the problems at present unsolved is whence comes this radioactive material, and what maintains its activity? For the most part, it gives us the characteristics of radium and in smaller degree those of thorium and uranium. The action of actinium has not yet been sufficiently pronounced to be recognized. Polonium is believed to be one of the transitional forms of radium. No other radioactive substances are yet known. The most important one thus far identified is radium. But the life and activity of radium is, from a geological standpoint, very brief. According to Professor Rutherford, and he is sustained by nearly all other physicists, radium is half consumed in a period of 1,300 years. In 13,000 years only the thousandth part of what now exists will be left, and in 26,000 years, only the millionth part will remain. Quite independently of geological reasons, the belief has been that radium is generated as the product of decay of some other element, and that the amount of it in nature is sensibly constant. It is generated as rapidly as it decays. The parent element from which it may be derived is not yet decided, but there are some who suspect it to be uranium, which has immensely long life. It requires nearly 120,000,000 years to be half consumed by its own decay.

But we are not interested in pursuing and trying to test these unsolved problems. It is enough for us that radioaction exists in suffi-

cient quantity and intensity to furnish heat enough to meet the wants of the vulcanologist.

Let us now look for a moment at the presumable details of the process. At a depth of two or three miles in the earth let us assume that radium is in process of being generated. It starts at once upon that process of transformation of which one stage is the production of the so-called emanation, which is a gas of very high density and great penetrating power and diffusibility. We know that the upper strata and soils everywhere contain it, and no reason appears why the same should not be the case with the rock beneath. Wherever the emanation penetrates, the break-up of its particles generates heat and the temperature rises in proportion to the amount of emanation which undergoes transformation in a given time, and falls in proportion to the rate at which it is conducted away. So long as the gain of heat exceeds the loss, so long will the temperature rise until it becomes sufficient to melt the rocks.

All volcanic lavas contain water and those whose reservoirs are near the surface contain a large amount of it. Those which have a deeper origin contain a smaller amount of it. The deeper lavas are hotter and are erupted with less violence and in greater mass than the shallow ones, and the reason is obvious.

AN ECLIPSE EXPEDITION TO SPAIN

By Dr. S. A. MITCHELL
COLUMBIA UNIVERSITY

IF we could sum up the total duration in minutes and seconds of recent eclipses, we should be astounded that astronomers from such phenomena have discovered so very much. Since the spectrograph and the photographic plate were first used together at an eclipse, the sun has been covered up by the moon somewhat less than twenty minutes of time, yet, in these few moments, a great wealth of information has been gained from the eclipsed spectrum. Each eclipse settles some problems, and teaches us how to attack others, and astronomers are most enthusiastic at such a time, trying new instruments and improved methods of research. More interest was shown in the 1905 eclipse than ever before, one reason for this being that the moon's shadow path fell upon a readily accessible part of the globe, and the eclipse occurred at a time of the year (August 30) when most college men were having their summer vacation. At the last eclipse, in 1901, American astronomers had to travel as far away from home as possible, in that a trip half way round the world was taken; and when one considers the number of instruments, and the great amount of freight that the modern astronomer has to carry with him, the task is no small one.

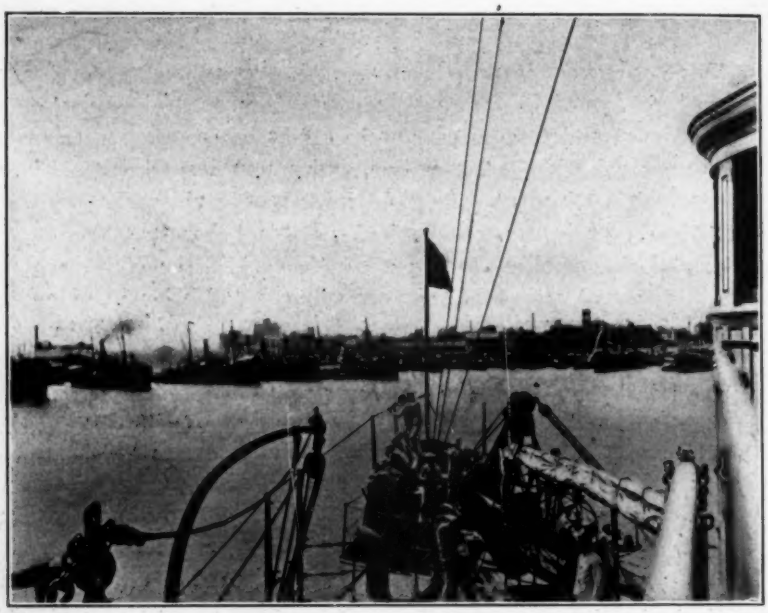
At the eclipse of last year the moon's shadow touched the earth's surface at sunrise in Manitoba, and after crossing through Canada at cannon-ball speed, it left Labrador about 8 A.M. on its trip across the Atlantic. Shortly after noon the shadow cut into Spain, then on through the Mediterranean, northern Africa, Egypt, and left the earth's surface at sunset on the coast of the Indian Ocean.

Spain was chosen by the majority of astronomers, both because the duration of totality was longer, and because the weather conditions promised better; and here in a path one hundred and twenty miles in width running diagonally across the peninsula, hundreds of astronomers, American and European, were gathered.

The party sent out by the United States government was under the general direction of Rear-Admiral Colby M. Chester, U.S.N., superintendent of the Naval Observatory. Three men-of-war were furnished by the Navy Department for the purposes of the expedition, the U. S. S. *Minneapolis,* U. S. S. *Dixie* and U. S. S. *Cæsar,* the first named being the flagship of the squadron.

The three vessels left separately from the United States about the end of June, and met in Gibraltar about the middle of July. 'Gib'

is one of the most interesting places in the world, especially when entering on a naval vessel. It was a glorious sight, as we steamed in at dawn, to behold the wonderful rock, and sheltered at its base the Mediterranean squadron of the British navy, consisting of eight battleships and eight first-class cruisers, under the greatest of English admirals, Lord Charles Beresford. The morning of our arrival was spent in firing and acknowledging thunderous salutes, and in making official calls. To properly carry out these acts of courtesy between the American and British nations, it was necessary to fire no less than one hundred and fifty-two rounds of ammunition. On the morning of our second day in Gibraltar, the British squadron sailed, and it gave us an



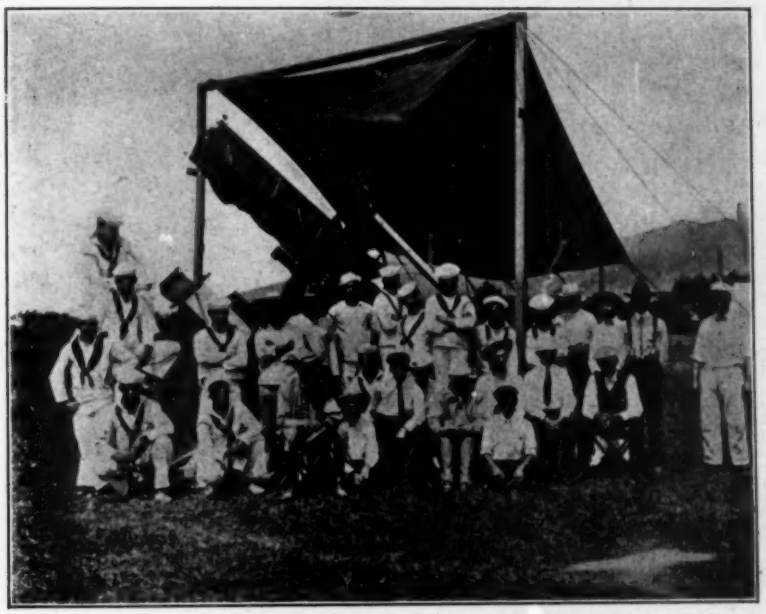
U. S. S. MINNEAPOLIS, ENTERING VALENCIA HARBOR.

idea of the quality of the greatest navy in the world to see the splendid, seamanlike manner in which the big ships got under way, and without confusion, and in splendid order one by one depart from the crowded harbor.

Gibraltar covers only about two square miles, so it did not take much time for us to take in all the sights of the streets with their motley population of English, Spanish and Moors, and to visit the places of historical interest. The 'Key of the Mediterranean' stretches almost exactly from north to south with a length of three miles and a breadth of little more than half a mile. The north and east sides of the 'rock' are almost vertical, while to the south and west it descends in step-like terraces, and thus it is only a small portion of the area of two square miles that is habitable. From the foot of Mt. Rockgun

(1,356 feet) the land stretches northward towards Spain in a low-lying flat isthmus not more than half a mile in width. The central portion of this, a third of a mile in width, is kept as a neutral zone between the Spanish and British possessions, and is lined with sentry boxes on either side. The fortifications of the side towards Spain consist mainly in galleries hollowed out in the face of Rockgun during the four years' siege ending in 1783. Signal Station (1,295 feet) and Highest Point (1,396 feet) are surmounted with great guns which defend the twelve miles of strait that flow between Europa point and Africa.

Entering the blue waters of the Mediterranean, the *Minneapolis* steamed along the coast of Spain for about four hundred miles and



ECLIPSE PARTY AT DAROCA.

anchored in the harbor of Valencia, the first American man-of-war to visit a Spanish port since the late unpleasantness.

At Valencia, the home of the 'Cid,' the annual fair was in progress, and the chief attraction was the bull fight. During the eight days of the fair, five *Corridas de toros* were held. Six bulls were killed at each of four of these fights, and in the other, 'extra-special' fight, eight bulls were slaughtered. Those of us who went to the first of these disgusting spectacles saw six bulls and nineteen horses butchered, and it is hardly necessary to remark that we did not go a second time.

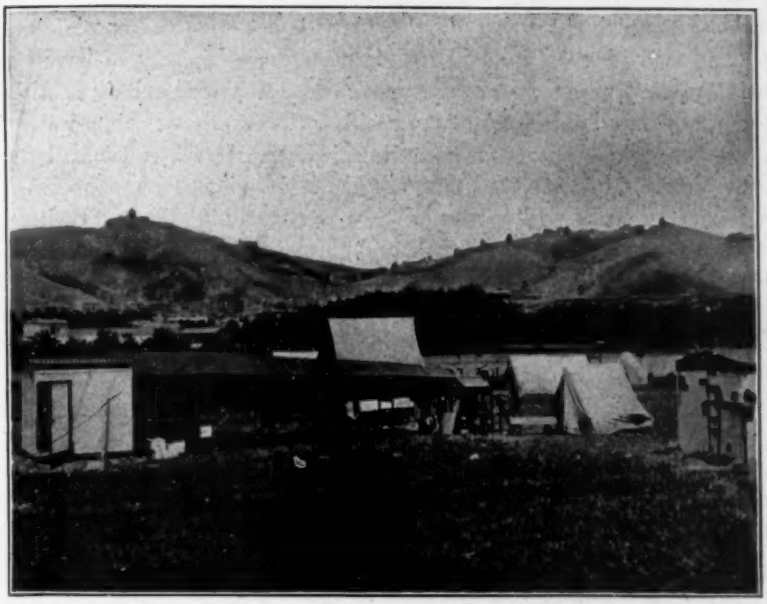
The bull ring is of the shape that the name signifies, the one in Valencia being the largest in Spain, capable of holding 17,000 people. The fight is opened by a procession into the ring of those taking part.

At the head of the procession walk the *Espadas,* then come the *Banderilleros,* the mounted *Picadores* and the attendants (*Chulos*) on foot with a team of gaily bedecked mules used in dragging off the dead bulls and horses. The fight can be described as follows:

It is one of three acts. In the first act the *picadores* receive the charge of the bull, which they try to withstand by prodding him with their pikes. In nearly every case horse and rider are overthrown by the bull, and the horse terribly gored. The bull's attention is attracted as quickly as possible by the waving of cloaks in the hands of attendants, and he is enticed to leave the prostrate man and horse. This performance is repeated several times until the bull becomes a little wearied. The second act now begins, and in this a *banderillero* on foot will meet the bull in full charge, stick into his neck on either side two barbed darts about thirty inches long covered with colored paper, and step nimbly aside to escape the enraged animal. Usually eight of these darts are used. In the third and last act, the *espada* teases the bull with his red cloth and manœuvers to get the weakened bull in a favorable position to give the death stroke by thrusting his sword through the neck and into the bull's heart. Great is the applause when the bull falls dead from a single stroke. The dead bull and horses are dragged out by the mule team, the ring is sanded to cover up all traces of blood, a new bull is let in and the fight goes on as before. (A bull fight is quite expensive. Each bull costs about $250, and horses, though poor, cost something. The animals killed in the ordinary *corrida* are worth at least $2,000.)

It had been decided to divide the Naval Observatory expedition into three, sending two parties to Spain and one to Africa. The U. S. S. *Dixie* took the African party to Tunis, and the astronomers Jewell, Gilbert and Dinwiddie located themselves at Guelma near the central line of the shadow cast by the moon. In Spain there were two parties, one located at the edge of the path of totality at Poerto Coeli, and the other near the central line at Daroca. At the former place were Lieutenant Commander Hayden, Professor Littell, Mr. Peters and Mr. Hill from the Naval Observatory, and Mr. Anderson from the Johns Hopkins University; at the latter place were stationed Professor Eichelberger and Mr. Yowell of the U. S. Naval Observatory, Professor Bigelow of the U. S. Weather Bureau, Mr. Hoxton of the Johns Hopkins University, and the writer.

Daroca is in the heart of old Spain, about forty miles from Saragosso, and as a railroad has been there only four years it is a *terra incognita* for modern tourists—for which we were duly thankful. Our six weeks' stay there was a happy commingling of hard work—and there was plenty of work to do—with pleasant experiences in getting acquainted with Spanish life and people. The site for the town is indeed a peculiar one, in a valley so surrounded by hills that each



ECLIPSE CAMP DAROCA, LOOKING NORTH.

heavy rain storm used to flood the city till, about 1600, a tunnel was constructed through one of the hills to carry away the waters. The tops of these hills are crowned with walls and forts, most of them constructed by the Moors a thousand years ago, some of them by the

ECLIPSE CAMP DAROCA, LOOKING EAST.

Catholic Spanish since that time. There is one tower of special interest, and still in good state of preservation, which is said to have been built by the Romans before Saguntum was founded, and it is, therefore, more than two thousand years old. (The railroad from Valencia passes through Saguntum where Hannibal and the Romans had their memorable fight in B.C. 238.)

The Spaniards received us with open arms and did everything in their power to assist in our work and to make our stay in their midst as pleasant as possible. As no one in the place could speak English, it was necessary to make ourselves understood in their language. They did not laugh at our mistakes in grammar or pronunciation, as we might have done in their places, but were always and at all times the souls of politeness and courtesy.

To help in the erection of the observatory, six sailors were sent in from the *Minneapolis,* and all hands, astronomers and sailors, worked each day from early morning till late at night, building piers, erecting telescopes with houses to shelter them, mounting spectroscopes, and fixing up a meteorological observatory. After the carpenters and machinists had finished their work of construction, it was necessary for the scientists to focus and adjust, to see that everything was in good working order, and to make trial photographs. A few days before the eclipse the party increased in size to thirty-five, officers and sailors having come up from the ship for the purpose of assisting in the observations. Frequent drills were held in order to familiarize each one with his part and thus to be sure that everything would go right and that no precious seconds would be wasted at the time of the eclipse.

There are certain things about the sun of which we still know very little: for instance, our information of the corona does not go very far. This wonderful halo, without doubt the most beautiful of all natural phenomena, can be seen only when the sun's light is totally eclipsed. As long as there is a slight trace of the sun's disc to be seen, its light is so overpowering that the corona is obliterated; but the instant the moon completely covers it up, there flashes out instantaneously the gorgeous crown of light to view which is well worth traveling thousands of miles. At this eclipse the corona lasted for three minutes and forty-five seconds, and almost with the first reappearance of the sun it was gone. Although this crown must be at all times around the sun, astronomers have not yet become expert enough to make it visible without an eclipse. The shape of the corona, too, is peculiar in that it is in some manner connected with the number of spots on the sun. When there are very few spots, the corona is winged out on either side along the sun's equator, while in the years that the spots are many, the streamers run out at all angles and the corona is more or less square in shape. We have known for more than fifty years that there is some close bond between the number of spots and the amount of magnetism

in the earth. This terrestrial magnetism is evidenced through changes in the compass needle, in frequent magnetic 'storms,' and in the beautiful northern lights. The sun spots are thus the seat of some great solar activity of whose exact nature we are at present not sure. Moreover, the sun is not sending to the earth a constant amount of heat. Very recent observations in Washington show that these solar fluctuations are followed very closely by variations in temperatures all over the earth. Whether these newly discovered variations in the sun's heat are connected with the spots on the sun, or not, it is too early to say, but it may not be outside the bounds of possibility to be able in the future to forecast the great variations in our earthly temperatures from observations on the sun. We realize, then, the importance of

NORTH GATE, DAROCA.

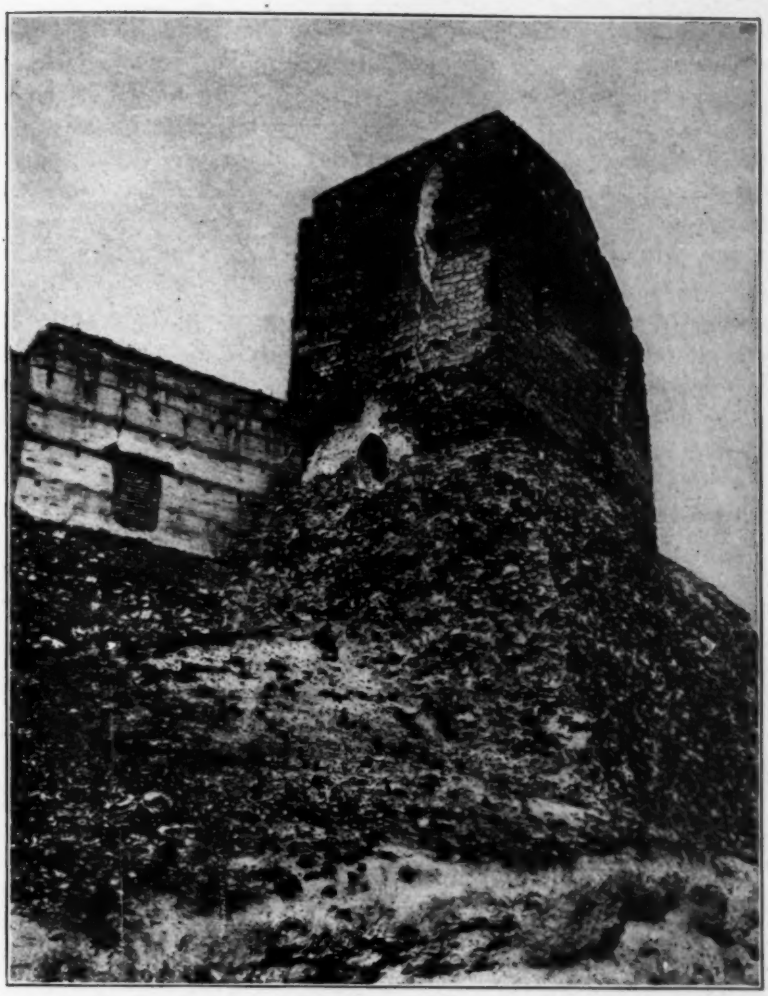
these observations on the sun, and it is for the solution of problems such as these that eclipse expeditions are sent out.

To investigate the corona, photographs are taken of all sizes. The diameter of the sun on the photograph depends on the length of the camera, the greater the focus the larger the sun. At Daroca the largest camera used was forty feet in length, which gave an image of the sun four inches in diameter. In photographing, the lens can be mounted pointing directly at the sky, or else the whole instrument can be placed horizontally and light be reflected into it by means of a mirror. We adopted the latter way as being the easier.

The location of the eclipse camp was half a mile south of the town, in the midst of a beautiful, fertile valley. From there, while we

worked, we could catch glimpses of scenery typical of Spain. The first feature to attract your attention is the extremely barren aspect of the country, which is in sharp contrast with the garden-like appearance of England. The hills of Spain were in early times densely wooded, but now are almost entirely devoid of trees and look from a distance as if there were not a particle of vegetation on them. Moreover, the rainfall is so slight that agricultural pursuits must rely upon irrigation for their carrying on, and thus it is only the valleys that are green and cultivated. In such a valley along the shores of the little river was our eclipse camp located. The greenest field was decided upon as the site of the observatory, and upon application to its owner for permission we found that he was quite satisfied to allow his plot of ground to be used, but thought some compensation should be made for the valuable crop of grass that might possibly be raised during the summer. On receipt of one hundred pesetas, he forthwith proceeded to take a fatherly interest in all of our doings, and explained scientific matters to every one as if he had been chief of the expedition. His field became the center of interest in the community, and people came from all sides to look upon the strange doings. As a prominent trait in the Spanish make-up is a great and overpowering curiosity, we had plenty of onlookers; and when the mayor and a few of the most prominent citizens were invited to look at the moon through our five-inch telescope, we were rather surprised—to put it mildly—to find over one hundred people turn up, when only a half score had been invited. Their curiosity took the form only of making each and every one in the town intensely interested in what was going on, and to show that interest they turned out in force each afternoon to see how matters were progressing. It might be asked, what was their attitude towards these Americans who had so lately beaten them in their small war. Before the expeditions reached Spain, it was feared that perhaps there might be some friction on that account, but these fears were not realized. As a matter of fact, the only person we met who seemed to have any feeling in the matter was a former soldier in the Spanish army. He had seen service in the Philippines, had been captured and thrust into prison by the Filipinos, had been rescued by the Americans, and as a result he had only the kindest of feelings towards everything belonging to the United States. As for the rest of the people, they seemed to have forgotten all about it, or else they did not know there had been a war, for it must not be forgotten that only about one quarter of the people in Spain can read and write.

Besides getting photographs of the corona of different sizes, the astronomers at Daroca were using the most powerful spectroscopes ever employed at an eclipse, for the purpose of investigating the nature of the light of the sun and its surrounding region. There are two ways of producing a spectrum. The best known method is by means



MORE THAN TWO THOUSAND YEARS OLD.

of a triangular prism of glass which breaks up the white light of the sun into its component colors of red, orange, yellow, green, blue, indigo and violet. The other and better way is by the use of a grating. Such an instrument is made by ruling on the surface of a plane or concave mirror many thousand fine lines separated by equidistant intervals. The writer had mounted for his use at the eclipse five spectroscopes, two being prisms, the others gratings. By means of these a great variety of problems were attacked, such as the constitution of the atmosphere immediately surrounding the sun and the heights in miles to which the different gases extend above the sun's surface, the nature of the gases that go to make up the beautiful corona, the amount of heat and energy of the corona, etc.

After this my third total eclipse, I can confidently say that observations at such a time consist of much hard work and many nerve-racking experiences. One is never on hand sufficiently long beforehand to take things quietly and easily, you must work under conditions you are totally unused to, and over your head hangs the knowledge that everything must be completed by a certain day and a certain hour, for the eclipse can not be postponed, and there is no second trial in case of failure. In addition to working hard all day as carpenter and instrument maker, the astronomer must stay up half the night adjusting his instruments on stars, so that during the last few days before the eclipse very few hours of sleep each night are obtained. However, in spite of the many difficulties that were continually cropping up, the mounting and adjusting the instruments were practically completed by August 25, when our observing party was swelled in numbers by the officers and men from the *Minneapolis*. From then till eclipse day the time was spent in putting the finishing touches on the work of adjustment, and in having frequent drills in order to insure that everything would go without a hitch.

Eclipse was to occur shortly after noon on August 30, and for many days beforehand we had been carefully scrutinizing the weather in order to see what conditions we might possibly have to expect. As a rule the sky was clear at eclipse time. It would have been dreadfully disappointing to have had a cloudy day, or even to have a stray cloud cover the sun during the important few minutes of the total eclipse. Such a thing happened at the last eclipse in 1901 after traveling half way round the world. Where some of the observers were, the sky was so overcast that it was impossible even to see where the sun was. At the 1905 eclipse darkness lasted for the space of three minutes and forty-five seconds, and it was only during these few minutes, after weeks and months of preparation, that the real work was to be done. August 29 had been cloudy all day so that on eclipse day we had to go to camp early to test our final adjustments, go through drills once more and to be sure that all the apparatus worked smoothly. The skies were clear and our hopes for success were high. Outside the roped-off enclosure, the whole town of Daroca was assembled, for it was naturally thought that nowhere could the eclipse be seen so well as where the astronomers were located.

At 11.52 A.M. a little shadow was seen on the western limb of the sun, and the eclipse had begun. The skies were clear with the exception of a cloud here and there, and our most ardent wish was that the clouds would leave the sun clear for the next couple of hours. For the first hour that the moon was creeping over the sun there was nothing of very great moment to notice, but for the next twenty minutes till 1.12, when the sun was blotted out, we were each of us filled with expectancy, for matters began to take on a weird and unnatural appear-

ance. The little blotches of light under the trees, instead of being the familiar circles, were little crescents, exact counterparts of the sun itself. The darkness began to make itself really felt, and without looking at the sun one would know that something out of the ordinary was happening, for the gloom did not in the slightest degree resemble that of sunset. A hush fell upon the crowd of assembled and talkative Spaniards when, ten minutes before totality, a big cloud drifted over the sun. Would this cloud move away? Or were we going to be disappointed? It hung there for a space of time that seemed to be an age, while in reality it was only five minutes. It was a big scare, but when

CORONA, August 30, 1905. 83 seconds Exposure. Photographed with a 40 ft. camera by W. W. Dinwiddie.

that passed, with a shout from us all, there wasn't another cloud anywhere to bother us. Fifteen seconds before the calculated time, with the last disappearing ray of sunlight, the corona broke forth into view. What a magnificent sight it is shining out with its pale, pearly light for a couple of diameters round the edge of the sun, with its streamers and brushes of delicate light! True to prediction, the corona was almost square in shape, and was not at all alike in appearance to the

other coronas the writer had seen in 1900, and 1901, with their long fish-tail extensions along the sun's equator and short-curved steamers near the sun's poles. In the upper left-hand quadrant huge red flames sixty thousand miles high could be seen with the naked eye, which with a closer view with the telescope resolved themselves into a forest-like structure. These we know are great jets of burning hydrogen gas. Close to the sun the corona was very bright, in fact so bright that the eye was not readily able to take in all the details of the faint streamers. As a pictorial effect without the long equatorial extensions, this corona was much inferior to the two last ones seen. Still it was a magnificent sight, and we were more than thankful for having clear skies to make our observations.

When totality first started we were each and all of us much too busy to take much notice of our immediate surroundings or even the corona itself. We could not help becoming aware that our Spanish onlookers outside the ropes were appreciating the show in the skies provided for them without expense. From the noise made each one seemed to be telling his neighbor at the top of his voice just how it happened and what there was worth seeing, and this in spite of the fact that the mayor of Daroca had generously provided half a dozen members of the civil guard to preserve order and keep quiet. For the first half minute the din was so great that it was impossible to hear the seconds counted, or to know exactly when to begin and end the exposures of the photographs, for at present-day eclipses all important observations are made by photography. The impressions received by the eye are so fleeting, coming to the observer when he is not in his usual calm, calculating mood, but aroused by excitement and novelty, so that it would be no wonder if in the past mistakes have been made in interpreting the celestial phenomenon. At present-day eclipses, with the aid of the photographic plate, the astronomer devotes his attention to getting a good series of photographs, and after the few minutes of the eclipse are over the plates can be developed and permanent records obtained which can be studied at leisure through weeks, months and perhaps years. When the Spaniards had quieted down, after their first outburst, all that was heard in the eclipse camp was the steady count of the observer calling out the seconds as they passed, the quiet words of the observers giving commands to their assistants and the click, click of the apparatus as exposures were made and plate holders moved. Everything passed off without a hitch, and with the first reappearance of the sun our work was over and we could take a long breath.

We had been favored with clear skies, how many others were equally fortunate? It did not take us long to find out, for the Spanish government had installed right in our camp a telegraph office, and for fifteen days no less than three operators were at our service to send and

receive our messages; and for this not a single cent of money was asked or expected. It was found that fifty miles to the west of us, at Alhama, where were the observers from the Lick Observatory under Professor Campbell, there were thin clouds, while one hundred miles to the east along the Mediterranean coast the Englishmen were even more unfortunate in having the clouds denser. In the northeastern part of Spain at Burgos more astronomers were located than at any one place, and here too was King Alfonso of Spain. Five minutes before totality it was pouring rain there, but as if by a miracle a little blue patch of sky appeared, and the eclipse was seen under perfect conditions. The weather along the eclipse track was: in Labrador, cloudy, no observations made; in Spain, cloudy and clear; in the islands of the Mediterranean, cloudy; on the coast of Africa, slightly cloudy; but further inland and along the rest of the eclipse track the skies were perfect. All three parties of the Naval Observatory were fortunate in having their work unhindered by a single cloud.

My own work was entirely spectroscopic. The photographic plates were developed within the walls of the college of Daroca, and in the long hours necessary for this work I was greatly encouraged and assisted by my good friend the rector of the college, Padre Felix Alvirez. Daily intercourse with this reverend father endeared him to me very much, and Srs. Lorente, Soria and Padre Felix made my stay in Daroca one of the most interesting spots of my whole life by the kindness with which they bore my imperfect Spanish, by the interesting bits of history they told of Daroca and by the deep insight each gave of the courtesy of a Spanish gentleman's heart.

The developed plates show that a great amount of detail had been caught, on one plate there being no less than twenty-five hundred lines all in good focus. A careful and accurate measurement made of the position of these lines of the spectrum will give much of scientific interest about the constitution of the sun's atmosphere.

As a result of the observations of this latest eclipse much valuable information will undoubtedly be gained about the sun and its immediate surroundings. These discoveries, however, will all be in minor details, and it is hardly probable there will be any wonderful or startling revelations made.

It is a long time till the next eclipse to be generally observed in 1912, and astronomers will have plenty of time to fully investigate their photographs of this past summer.

The instruments that took weeks to mount and adjust were easily pulled apart and packed, and in a few days after the eclipse everything was in readiness to be transshipped home.

The writer left Spain with many regrets, and with many happy recollections of a pleasant and profitable time spent among the courtly Spaniards.

SHORTER ARTICLES

THE SPANISH AMERICAN TYPE

THE twenty portraits reproduced here are those of Central American students taken in a haphazard way in a Costa Rican government college. The composite photograph expresses well enough the features common to most of them: the large, dark, dreamy eyes and the relief of both mouth and chin. It may be considered as a good illustration of the Spanish American type. Mexico receives an increasing American element; Brazil and Chile are somewhat Germanized; Argentine is flooded with Italians; in Central America, the race, the habits and the language are still comparatively free from foreign admixture.

By foreign I mean exotic. A stream of Indian indigenous blood flows in the veins of a large number of Central Americans. It reveals itself here and there on some of the faces which surround our central picture.

Aside from that occasional modification the Spanish American is not unlike his Spanish cousin. His features are those of the Mediterranean race. His skull is dolichocephalic. His body is slender. The stature is variable although generally inferior to that of the Baltic race. The circumstances

COMPOSITE PHOTOGRAPH GIVING THE TYPE OF THE SPANISH AMERICAN STUDENT.

which determined the migration from Spain were not such as to induce a physical divergence between the two branches. In other words, those who departed did not differ in bodily appearance from those who remained.

They differed greatly in mental propensities. When, under the reign of Charles I., marvelous stories concerning the strange and beautiful lands discovered by Columbus, Cortez and Pizarro were circulated in Spain, excitement prevailed all over the peninsula. The practical, matter-of-fact people smiled with incredulity, but the imaginative, the chivalrous, the restless, sold all and sailed. Here is the main fact which is to borne in mind when the present nature and tendencies of the Spanish Americans are considered. Restless, alas! they are and somewhat restless they may remain, yet they are neither dull nor obstinate; they see their worst defect as clearly as others see it and try to overcome it. If strifes are still frequent among them, on the other hand, the first international treaty of permanent arbitration was the work of two Spanish American countries, and that treaty was by far more comprehensive, and thereby more efficient, than any of the similar treaties recently made in the northern hemisphere.

Restless and not practical, but also warm hearted, impulsive and generous, in olden times, many Spanish noblemen sailed because they felt sure to find in the American Eldorado the fountain which confers perpetual youth on all who bathe in it. They went through many vicissitudes, became old and died far away from the land of their fathers without having realized their dream, but it seems to-day as if some of the marvelous waters were present in all the rivers which run down from the Andes, for the defects of the Spanish American, as well as his qualities, are but those of youth.

GUSTAVE MICHAUD.

THE PROGRESS OF SCIENCE.

THE EARTHQUAKE ON THE CALIFORNIA COAST

IT is too late to describe here the appalling disaster that has overtaken San Francisco and the neighboring regions and too soon to attempt to present a scientific survey of the causes leading to the catastrophe and the precautions that should be taken to avoid its recurrence. We can but add one more expression of the universal sympathy and a further appreciation of the undaunted courage which leads men to assert their supremacy even in the face of the most terrible exhibition of the powers of nature.

The progress of science and the conditions of modern civilization have been the chief causes of the calamity; yet we may confidently look to the same factors to prevent its recurrence. Earthquakes occur daily, and a shock such as that of April 18 would have done but small damage to a farming community. The trouble was due, on the one hand, to large piles of masonry or flimsy brickwork unsuited to resist vibrations, and, on the other, to the conflagation. The live electric wires, the methods of heating, lighting and applying power, the dependence of a modern city on its fire department and a supply of water through mains, not only explain the San Francisco fire, but made it almost inevitable. On the other hand, the steel frames and concrete reenforced with steel wires, proved themselves, as had been foreseen, well fitted to resist destruction. The only trouble was the shaking off of the stones and bricks and the inflammable contents. If it were not for the esthetic effects, such buildings might be covered with metal sheathing and be made fire-proof within as well as without. They would then be earthquake-proof—at least for such shocks as are known to have occurred—and would be as effective as open spaces in stopping the spread of a conflagation. San Francisco will take all needful precautions. Whether cities less likely to suffer should do so is more doubtful. The effects of an earthquake in New York City would be appalling. The people would rush into the streets, too narrow to hold them, while the stones would be shaken down on their heads, the conditions being similar to those of a vast theater fire. But more lives are needlessly sacrificed in New York City each month than have been lost in the California disaster, and more money is wasted each year than is needed to rebuild San Francisco.

The causes of earthquakes are somewhat obscure and are doubtless of different kinds. They are part of the vast terrestrial phenomena which have lifted the continents and the mountain ranges. The main stresses may be due to contraction of the crust of the earth or to changes in its shape, while the proximate causes are the local geological formations. The conditions at San Francisco are fairly well understood. There is a fault in the peninsula along the Portolá Valley, where for about forty miles the rocks on one side have at some time sunk two thousand feet. At the time of the recent earthquake, the land on the west side of the fault was forced northward from three to six feet, and the violent dislocation accounts for the shock. Mr. G. K. Gilbert has been instructed by the U. S. Geological Survey to make a thorough study of the causes, and we

may be able to print a special article on the subject in due time. In the meanwhile there is given above an article by Professor Turner on our present knowledge of earthquakes. There is also printed in this number of the MONTHLY a paper by Major Dutton suggesting a hypothesis to account for the allied phenomenon of volcanoes. Those of our readers who wish to inform themselves on the nature of earthquakes and the methods of recording and studying them should read the book on the subject by Major Dutton, recently published in the 'Science Series' by the Putnams.

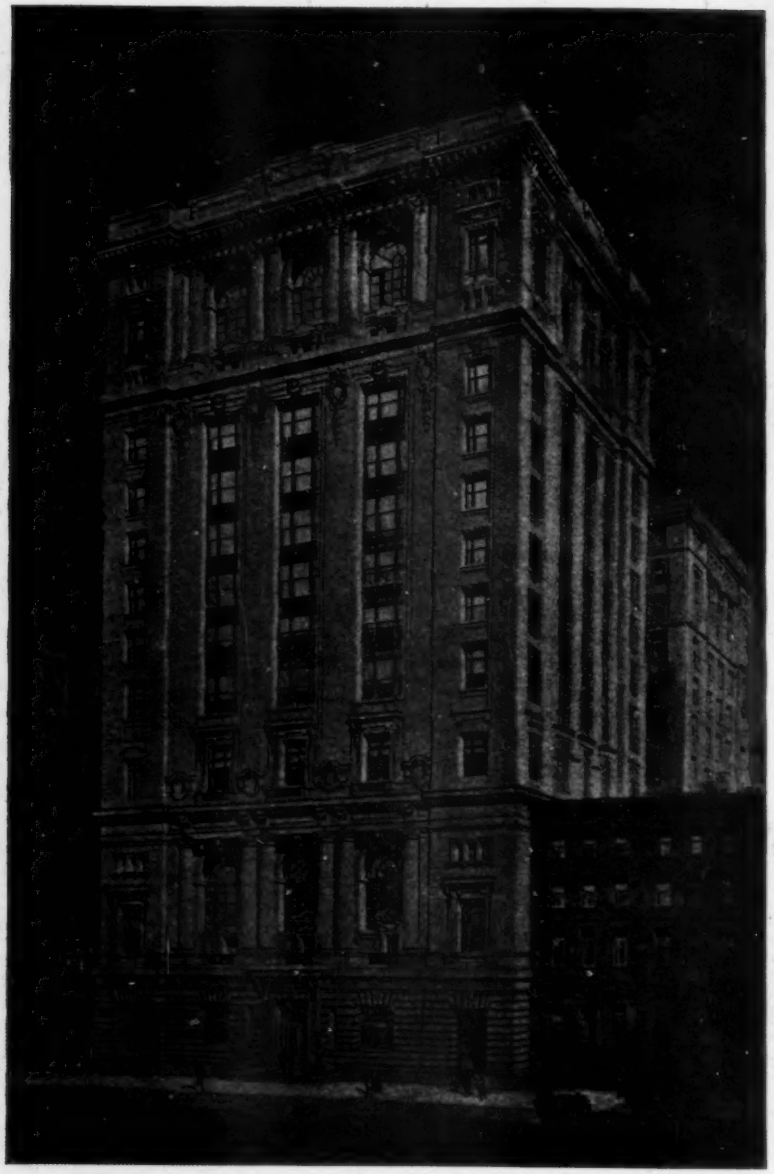
THE ENGINEERING BUILDING OF NEW YORK CITY

THE corner stone of the United Engineering Building in New York City, already more than half completed, was laid on May 8 by Mr. Andrew Carnegie, to whose munificence the building is due. It will be remembered that, in view of Mr. Carnegie's gift of one and one half million dollars, the United Engineering Society was incorporated on May 11, 1904, under the legislature of the state of New York for "the advancement of the engineering arts and sciences in all their branches, and to maintain a free public engineering library." The 'Founder Societies' represented in the corporation are the American Institute of Electrical Engineers, the American Institute of Mining Engineers and the American Society of Mechanical Engineers. The building of the United Society will provide permanent headquarters for these three national engineering societies and for the Engineer's Club, and also places of meeting and office room for such other engineering and scientific societies as may from time to time be admitted as 'associates.' Power to administer the trust is invested in a board of trustees of nine members, consisting of three representatives elected by each of the Founder Societies. The expense of maintenance must be shared by the three societies participating in the foundation, in accordance with regulations imposed by the United Society. The following are the charter members of the corporation: Charles F. Scott, Bion J. Arnold and S. S. Wheeler, of the American Institute of Electrical Engineers; C. W. Hunt, F. R. Hutton and James M. Dodge, of the American Society of Mechanical Engineers; A. R. Ledoux, Charles Kirchoff and Theodore Dwight, of the American Institute of Mining Engineers.

The building of the new society is in process of erection on the north side of thirty-ninth street, between Fifth and Sixth Avenues, the site covering five city lots with a total front of 125 feet and a depth of 100 feet. The new building utilizes only 115 feet of the front and as it controls the other side, space is left on all sides of the granite pile of thirteen stories, which thus presents an imposing monumental appearance. The plans are entrusted to Messrs. Hall and Rogers, and Henry G. Morse, associate architects, for the three engineering societies and Messrs. Whitfield and King for the Engineering Club. The building, as shown in the illustration, is a notably worthy product of the modern science and art of building construction that may well serve to typify the purposes for which it was conceived.

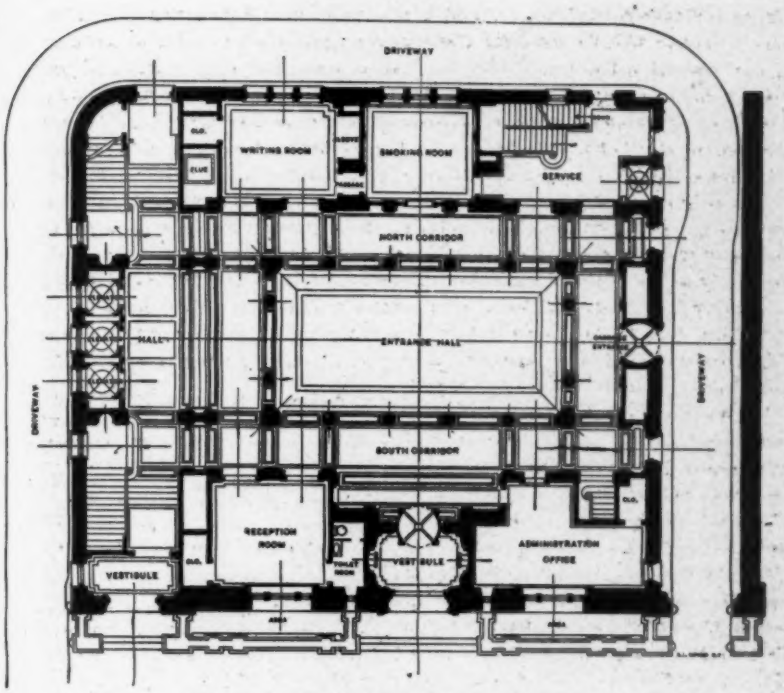
Primarily it must serve the convenience of the individual societies which enter it as founders. To this end a floor provides adequate rooms for each of the societies, as shown in the case of the electrical engineers in the accompanying plan. In addition meeting rooms and auditoriums are to be furnished for the regular and special meetings of the societies and for scientific lectures and demonstrations. Other assembly rooms have been specially adapted to suit the various uses for which they may be required.

There is one large auditorium with accommodations for 1,000 persons, on the first floor above the street. The foyer and corridors afford ample space for withdrawal from the assembly hall,

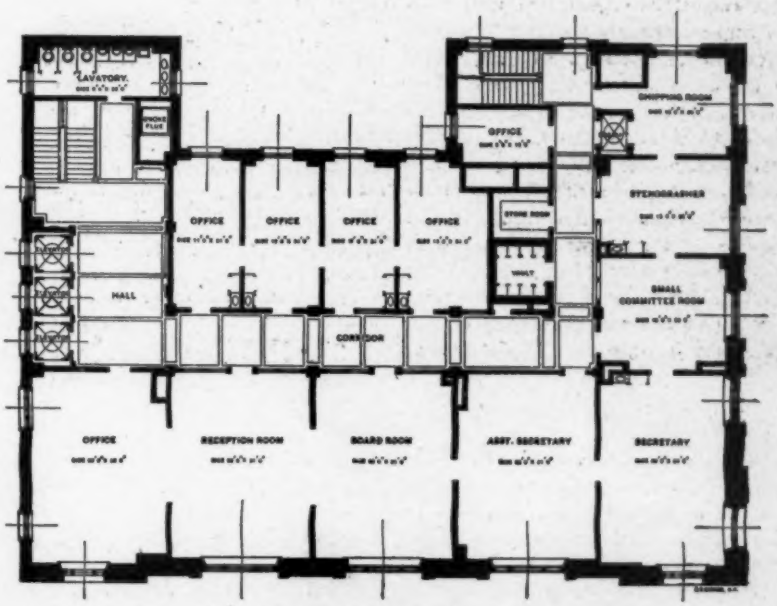


THE ENGINEERING BUILDING.

which offers means of exit at all four corners. The seats are arranged on a grade conforming to the modern practise in theaters. On the floor above are two assembly rooms with a seating capacity of 450 and 300 persons, respectively, which may be used, as preferred, independently or together. Smaller assembly, conversation and service rooms adjoin. On the floor above are lecture rooms for smaller meetings or for the sectional meetings of large organizations. These will be supplied with electric current, with compressed



ENTRANCE FLOOR OF ENGINEERING BUILDING.



TENTH FLOOR, OCCUPIED BY THE ELECTRICAL ENGINEERS.

air and also gas and water, and all meeting-rooms will be fitted for the use of the projection lantern.

Commodious provision is made for the libraries of the various societies on the two upper floors. The entire top floor, for which the best possible illumination will be provided, is to be given over to the great library hall and its auxiliary rooms, while the floor immediately below the reading rooms will ultimately be used for book stacks. Facilities for photographic reproduction, drawing and the like are also provided.

Eight alcoves open into the large central library room, devoted to general reference books, reference periodicals, the books of the American Institute of Electrical Engineers, of the American Society of Mechanical Engineers and of the American Institute of Mining Engineers and to the periodicals of each of these three societies. The union library thus arranged for should be of immense service to each of the societies represented and extremely useful to the whole engineering profession. The public will be given free access to the most important engineering library in the country.

It is expected that the building will, by the office and meeting accommodations it is designed to offer, prove an important means of advancing the interests of numerous engineering and quasi-engineering societies and indirectly of promoting the solidarity and efficiency of the scientific profession of engineering.

THE CARNEGIE FOUNDATION FOR THE ADVANCEMENT OF TEACHING

THE trustees of the Carnegie Foundation have adopted rules for granting retiring allowances which are characterized by foresight and wisdom. The question of charity has been so carefully eliminated that the plan will dignify the profession of teaching and will directly and indirectly improve the conditions in our institutions for higher education. There remain, of course, the fundamental issues between variety and uniformity, flexibility and permanence, autonomy and centralization, individualism and socialism. It can not be doubted that this great foundation favors centralization and a caste of professors. But there seems to be no other solution of the complicated problems of modern civilization than industrial socialism relieved by intellectual individuality.

The provisions for granting normal retiring allowances are as follows:

1. A normal retiring allowance is to be awarded to a professor in an accepted university, college or technical school, on the ground of either age or length of service. The term professor, as here used, is understood to include presidents, deans, and other administrative officers, professors, associate professors and assistant professors, in institutions of higher learning.

2. Retiring allowances shall be granted under the following rules, upon the application of the institution with which the professor is connected.

3. In reckoning the amount of the retiring allowance the average salary for the last five years of active service shall be considered the active pay.

4. Any person sixty-five years of age, and who has had not less than fifteen years of service as a professor, and who is at the time a professor in an accepted institution, shall be entitled to an annual retiring allowance computed as follows:

(*a*) For an active pay of sixteen hundred dollars or less, an allowance of one thousand dollars, provided no retiring allowance shall exceed ninety per cent. of the active pay. (*b*) For an active pay greater than sixteen hundred dollars the retiring allowance shall equal one thousand dollars, increased by fifty dollars for each one hundred dollars of active pay in excess of sixteen hundred dollars. (*c*) No retiring allowance shall exceed three thousand dollars.

5. Any person who has had a service of twenty-five years as a professor, and who is at the time a professor in an accepted institution, shall be entitled to a retiring allowance computed as follows:

(*a*) For an active pay of sixteen hundred dollars or less, a retiring allowance of eight hundred dollars, provided that no retiring allowance shall exceed the active pay. (*b*) For an active pay greater than sixteen hundred dollars, the retiring allowance shall equal eight hundred dollars, increased by forty dollars for each one hundred dollars of active pay in excess of sixteen hundred dollars. (*c*) For

each additional year of service above twenty-five, the retiring allowance shall be increased by one per cent. of the active pay. (*d*) No retiring allowance shall exceed three thousand dollars.

6. Any person who has been for ten years the wife of a professor in actual service may receive during her widowhood one half of the allowance to which her husband would have been entitled.

7. In the preceding rules, years of leave of absence are to be counted as years of service but not exceeding one year in seven.

8. Teachers in the professional departments of universities whose principal work is outside the profession of teaching are not included.

9. The benefits of the foundation shall not be available to those whose active service ceased before April 16, 1905, the date of Mr. Carnegie's original letter to the trustees.

Institutions supported by the state were excluded by the terms of the original gift, but this provision has not been included in the act of incorporation and the question is under consideration. Institutions controlled by a religious organization, requiring sectarian tests, or teaching distinctly denominational tenets are excluded. The fact that a university such as Chicago is excluded, while a college whose spirit is essentially sectarian may be accepted, will at first work inequality, but the institutions will doubtless adjust themselves to the conditions. It would probably have been better if the denominational question had been ignored. A sectarian university is a contradiction in terms, as an institution can not be at the same time sectarian and a university, but under existing conditions a certain amount of denominational control seems to be innocent enough, especially in the case of small colleges. The definition of a college, based in part on the New York state ordinance, is as follows:

An institution to be ranked as a college, must have at least six professors giving their entire time to college and university work, a course of four full years in liberal arts and sciences, and should require for admission, not less than the usual four years of high school preparation, or its equivalent. A technical school, to be eligible, must have entrance and graduation requirements equivalent to those of the college, and must offer courses in pure and applied science of equivalent grade. To be ranked as a college an institution must have a productive endowment of not less than two hundred thousand dollars.

SCIENTIFIC ITEMS

WE regret to record the deaths of Professor Israel Cook Russell, head of the Department of Geology at the University of Michigan, of Walter F. R. Weldon, F.R.S., Linacre professor of comparative anatomy at Oxford University, and of M. Pierre Curie, professor of physics at the Sorbonne, Paris, eminent with Mme. Curie for the discovery of radium.

STANFORD UNIVERSITY suffered severely by the recent earthquake, the loss being estimated at nearly $3,000,000. The buildings totally wrecked are the church, the memorial arch and the new library and gymnasium buildings. The buildings occupied by the laboratories and lecture rooms are not seriously damaged, and the university will be able to resume its work at the opening of the next term on August 23. The University of California suffered but little injury, either at Berkeley or San Francisco. Buildings owned by it in San Francisco, however, were destroyed and will seriously curtail its income, which will also suffer by the decrease of taxation in the state, unless this is made good by the legislature. The University of the Pacific suffered to the extent of about $60,000 with its buildings and collections. The building of the California Academy of Sciences was completely burned, but the type specimens and records were saved.

THE New York legislature has passed a bill providing for a new building for the State Museum, State Library and the Education Department, to cost not more than four million dollars. The bill carries an appropriation for the acquisition of a site and the preparing of plans. The legislature also passed a bill to acquire Watkins Glen, one of the ravines running into the Finger Lakes of western New York, for a state reservation. This region was described

by Professor Tarr in the last issue of the MONTHLY.

DR. E. RAY LANKESTER, director of the British Museum of Natural History, has been elected president of the British Association for the meeting to be held this year at York.—Dr. Henry H. Donaldson, since 1892 professor of neurology at the University of Chicago, has been elected professor of neurology at the Wistar Institute of Anatomy, Philadelphia.—Dr. K. E. Guthe, associate physicist at the National Bureau of Standards, has been appointed professor of physics and head of the department of physics at the State University of Iowa.

THE late Stephen Salisbury, of Worcester, Mass., has bequeathed the residue of his estate to the Worcester Art Museum, which, it is said, will receive more than $3,000,000. Many other public bequests have been made by the will, including, in addition to $200,000 to the Worcester Polytechnic Institute, some $250,000 to the American Antiquarian Society and $5,000 and a site for a building for the Worcester Natural History Society.

THE yacht *Galilee*, engaged in the magnetic survey of the North Pacific Ocean under the auspices of the Department Terrestrial Magnetism of the Carnegie Institution of Washington, arrived at San Diego some time ago, having completed a successful series of magnetic observations embracing the regions between San Francisco, San Diego, Honolulu, Fanning Island and the magnetic equator.—Dr. Sven Hedin has proceeded to Persia, where he proposes to explore thoroughly, from a scientific point of view, the salt deserts of Dasht-i-Kavir and Dasht-i-Lut in the eastern part of the country. He hopes afterwards to proceed through Afghanistan to India, and there organize an expedition for the exploration of Central Tibet.—Professor C. S. Sargent, of Harvard University, has sailed for Chili and the mountains of South America to obtain specimens for the Arnold Arboretum.

THE endowment fund for increase of salaries, at Harvard University amounts to nearly $2,300,000. The scale of salaries is to be as follows:

Instructors:	
Upon appointment	$1,200
Yearly increase	100
Maximum	1,500
Assistant Professors:	
In the first five-year term	2,500
In the second five-year term	3,000
Associate Professors:	
Upon appointment	3,500
Maximum	4,500
Professors:	
Upon appointment	4,000
Maximum	5,500

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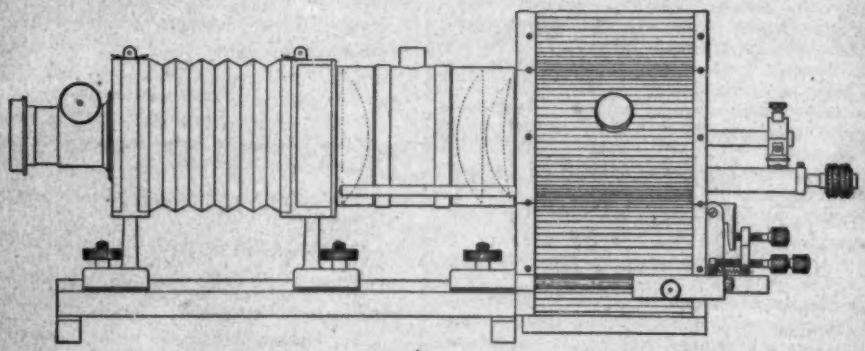

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